5 TIP AT TRANS 6 BOOKLET 12 POWER UNIT 16 CAT & DATA BOOK 14 SOUND GEN. SAA 1099

28 COMPUTER MUSIC GEN

36 MIDI CODE GEN. 50

61 TONE DECODER & RECEIVER

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Elektor Electronics

April 1988

Radio communications of the future

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Active loudspeaker system

MIDI code generator

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COMPUTER CONTROLLED SLIDE FADER

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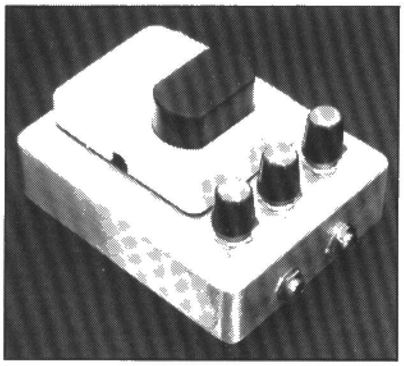
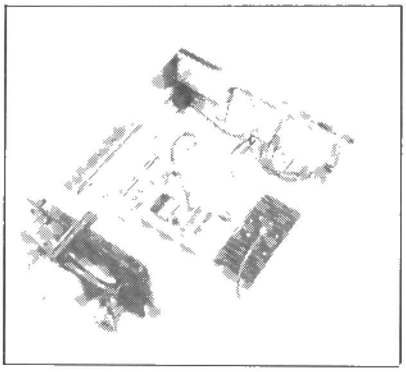
CONTENTS

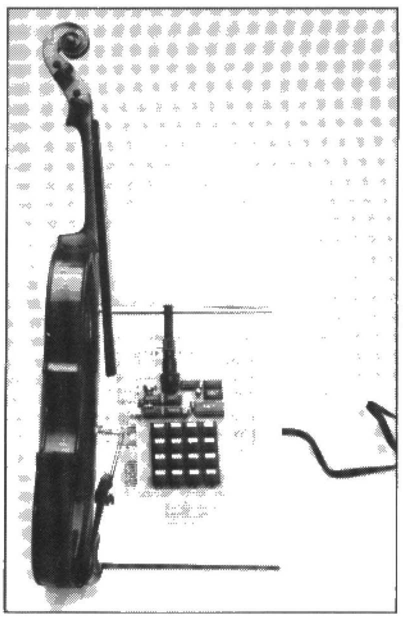
April 1988
Volume 14
Number 155



Fuzz unit for guitars
p. 33



Radio communications for the future
p. 54



MIDI code generator
p. 36

In next month's issue:

The main theme will be **Artificial Intelligence**; other articles will include:

- Plotter
- Digital optical transmitter*
- VLF convertor
- Signal processing and electronic encryption
- Microcontroller-driven PSU

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* We regret that owing to lack of space this article could not be included in the April issue as originally planned.

Front cover
Experimental set-up of four slide projectors driven by the computer-controlled slide fader described in our March and April 1988 issues

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THE STANDARD OF SOFTWARE

Software is a 'written' instruction used by people to tell computers what to do. In principle, the creation of such an instruction, or program, is fairly simple. None the less, even today, after nearly 40 years of programming history, nobody can write programs that are free of bugs. Worse, there is, as yet, no easy way of determining the likelihood of software failure before it is taken into use.

Yet, the way to reliable software was pointed out almost twenty years ago by a number of computer scientists of international repute who had become seriously concerned about the quality of software. Then, as now, most programs were produced empirically, and consequently they were not normally correct the first time they were used in practice. All the programmers could do was to add more instruction – a patch – and hope for the best. This method of programming has changed remarkably little in the intervening years, particularly when viewed in the light of the other tremendous changes in computer engineering that have taken place in those years.

Those scientists in the late 1960s suggested a new approach to programming and called it software engineering. This approach is aimed at putting software design and production on similar theoretical foundations and practical disciplines as, for instance, electrical and electronic engineering. Unfortunately, the mathematics on which computer programs are based is difficult. Whereas electrical/electronic engineering uses analytical mathematics, software engineering uses logic. Logic is a rigid discipline: whereas analytical methods allow a certain measure of flexibility, logic does not. This means that even a tiny error in a logic argument can upset the whole.

Furthermore, the testing of a long program by logic is beyond even most mathematicians. This gives programmers, who, in the main, are not trained in mathematics, let alone logic, not much of a chance. The unfortunate result for the customer is that programs are tested to only a limited degree.

By the proper use of software engineering, it has become possible to write much more reliable – but not yet completely error-free – programs. One of the ways this is done is by the use of a formal specification language, which results from rigorous academic work. Researchers in Europe and the USA have invented several of these. The improvement in quality of the resulting software on both sides of the Atlantic has been encouraging.

All of this, coupled with the efforts of the big software houses to design and produce integrated software, implies, of course, that programmers have to become more disciplined and trained in the rigorous demands of software engineering. No doubt, the majority of the estimated 60,000 or so professional programmers in the western world will be loath to admit, let alone accept, this.

Yet, it is clear that software buyers have a right, like any other buyer of goods or services, to demand that the expensive programs they are getting work properly. Not surprisingly, much software is sold with a disclaimer of warranty. Why do we go on accepting this? Only when we, the customers, in the knowledge that the quality of software can be improved to a significant degree, demand guarantees as to the quality of the software we buy, will software houses be prompted into the proper use of software engineering or run the risk of costly litigation.

A NEW MULTILAYER PROCESS FOR INTEGRATED PASSIVE DEVICES

by Dr. Gordon R. Love

This article describes a new process, derived from techniques used to produce multilayer ceramic capacitors, which is the key to a technique, known as Multilythics®, allowing complex integrated multi-functional passive circuits to be produced.

Introduction

There are two fundamentally different build-up processes for multilayer ceramic devices or assemblies. Each begins with a slip of finely divided ceramic particles dispersed and suspended in a complex organic system. In the more commonly used process, this slip is cast in thin sheets of controlled thickness and dried; patterns are then printed on it by thick-film silk-screen processing, and the array of finished devices is assembled by stacking and laminating these single sheets. This process is generally known as dry stack or 'tape' manufacturing.

The alternative process involves casting the slip onto an inert carrier, drying it, printing the patterns by thick film processing, and then casting the next controlled thickness layer *in situ*. This build-up process is then repeated as many times as is necessary. This technique is known as wet stack or 'paint' processing.

These two manufacturing processes cannot easily be compared, as each has its own strengths and weaknesses. For example, single sheets can be inspected and discarded if found defective in the tape process, whereas in paint processing this is virtually impossible. On the other hand, tape processing requires high precision at two distinct processing steps (printing and stacking), whereas paint processing requires high precision only at the printing stage.

Process differences

For both manufacturing processes, a minimum amount of organic binder is required both to encourage device formation and to facilitate the eventual binder removal. Binders free of metallic contaminants are preferred because they are less likely for contaminate the ceramic formulation, and they should be removable completely and easily because they must not distort the ceramic or

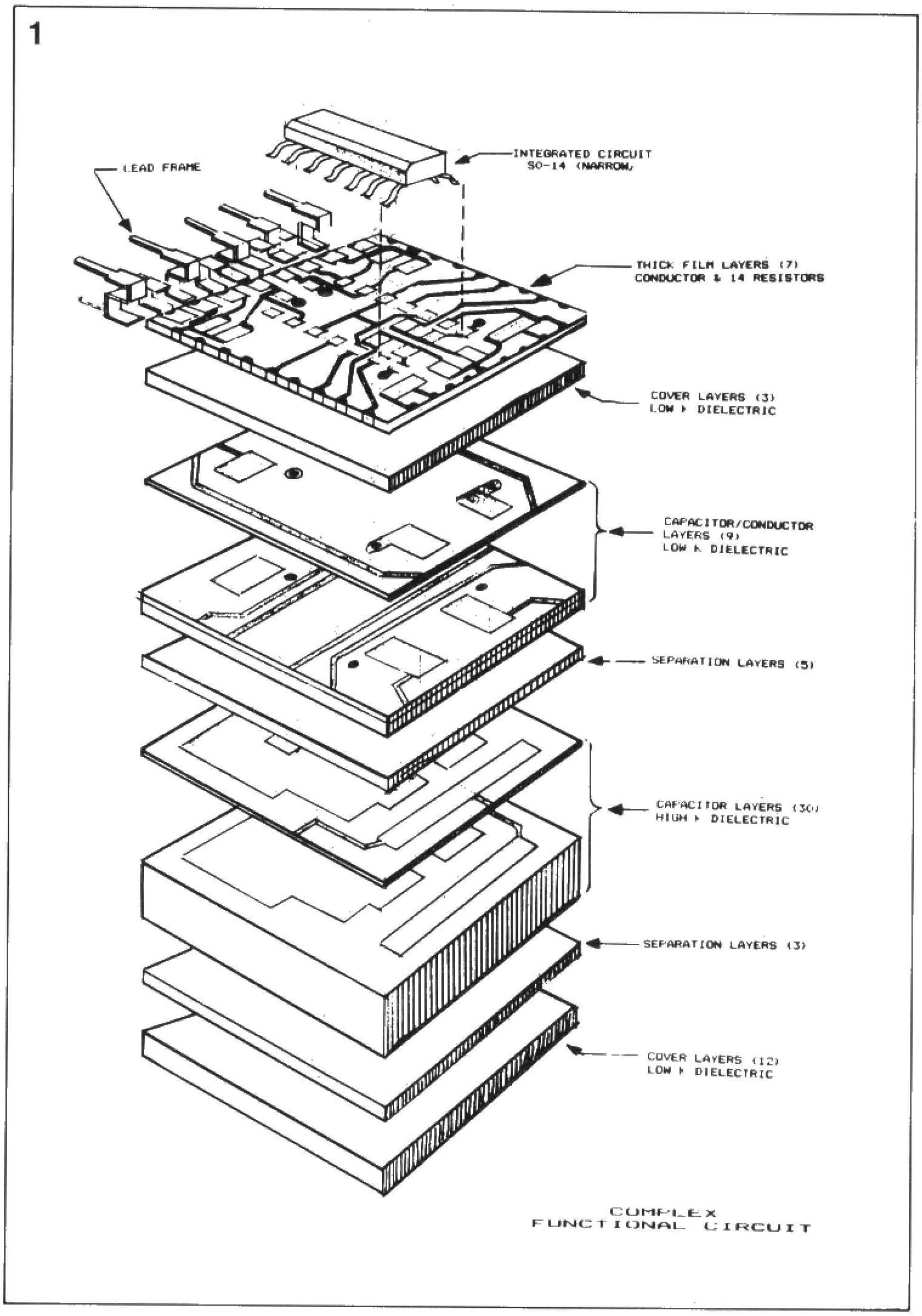


Fig. 1. Cross sectional schematic of a Multilythic device.

leave refractory residues which might interfere with the sintering process.
These binders and the associated solvents should be cheap, non-toxic, and easy to dry without film formation or cracking; moreover, the binder for the ceramic powders must be compatible with the (usually different) binder selected for the metal powders.
For a tape-based system, the organics must have excellent strength because the tape is handled as a self-supporting sheet for at least part of the process. In addition, many variations on the tape process involve locating the tape for printing or laminating (or both) by mechanically contacting the tape itself. Hence, reference holes must be both well defined and dimensionally stable.
In what appears to be a relatively fundamental conflict with these requirements, the tape has to be sufficiently plastic to permit very-high-quality lamination; otherwise, the sintered body can become vulnerable to internal lenticular voids or 'delaminations'. The tape binder should be relatively insensitive to variations in ambient temperature and humidity, in order to maintain the dimensional stability required between the multiple precision steps in the process.
For a paint-based system, dimensional stability and reproducibility are determined largely by the carrier plate, and all strength requirements are essentially met by the carrier. In addition, since the structure is assembled *in situ* with each layer being solvent bonded to its predecessors, plastic deformation is not required, and this source of 'delaminations' does not exist.
On the other hand, since visual inspection for pinholes and other casting/drying defects becomes impracticable, it becomes essential for high-quality layers to be obtained every time. High-speed drying is more important in this process because paint drying cannot easily be isolated from the rest of the build-up process, and so can limit production rates and overall productivity.

Quantum improvements

Wet-build processing has been successfully employed in the capacitor industry for over 25 years, and a combination of organic chemistry expertise and mechanical engineering skills has recently introduced quantum improvements to the basic process.
The latest generation of process developments has resulted in a technology that is specifically optimized for both printing and print location accuracy, as well as for uniform high productivity for both large and small manufacturing runs. The new technique is sufficiently different to warrant its own name: P-4 (for Precision Paint & Print Process) manufacturing.

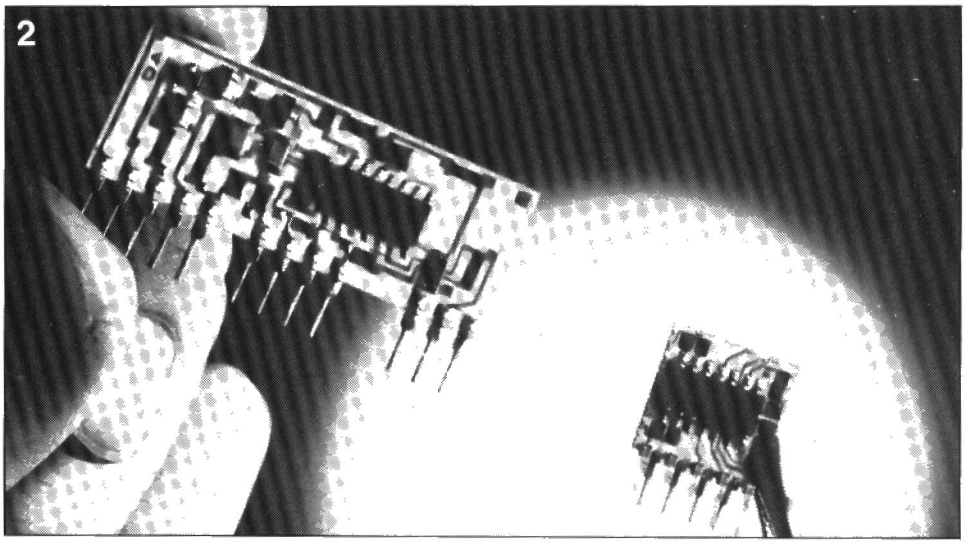


Fig. 2. Typical Multilythic devices.

This new process is crucial to a new manufacturing technology, known as Multilythics, which combines the diversity of materials used in the thick film industry with the economics of manufacturing and the complexity of finished devices inherently available from multilayer ceramic capacitor manufacturing processes.
The Multilythic technique allows many different passive functions to be integrated into the device 'substrate', so that the exterior surface of the device need only support active devices, special components like crystal oscillators, and devices requiring precision trimming. As a result, the size of assembled circuits can be significantly reduced, and this size reduction also offers major improvements in high-frequency performance.
Another benefit of this technology results from the incorporation of multiple components into the device, and hence a reduced number of interconnections which, in turn, improves the device reliability through assembly and in service. In addition, the small size, coupled with economies of manufacturing scale, should make the technology cost effective.
A typical Multilythics device (Figs. 1 and 2) incorporates low-K dielectric cover layers, high-K dielectric capacitor layers, low-K capacitor conductor layers, thick film conductor and resistance layers, and semiconductor components. The proprietary materials used in the process can be sintered to very high densities, and their electrical performance can be established very accurately and consistently. The large number of layers used in a typical device can be stacked with excellent precision in the 'green' or unfired state, and then fired a single time with uniform shrinkage.

Process benefits

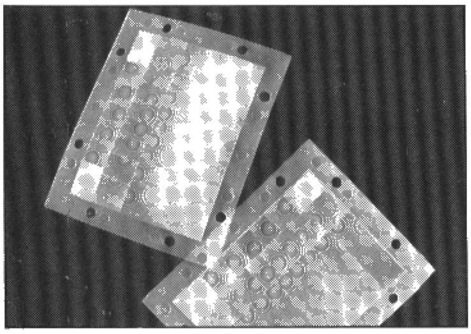
The high dimensional stability and high yields produced by the P-4 process are absolutely essential to the Multilythics concept. Because a Multilythic device is an array of components rather than a discrete device, the whole array must be discarded if a single component in the array is defective. Hence, if array yields are to be acceptable, single component yields must be very high.
By way of illustration, if the component yields are 95%, an array of 100 components would have a yield of 0.59%; a 99% component yield would improve the array yield to 36.6% etc. The P-4 process has been found to lead to satisfactory yields.
Another benefit of P-4 assembly is modularity. Historically, a major limitation of wet-build processes has been their relative inflexibility. Where unit volumes allow the assembly process to be run at its optimum throughput, it can be extremely productive, and efficient in both labour and capital investment. However, small runs can be made only by 'idling' major components of the manufacturing line for significant lengths of processing time.
By re-configuring the assembly equipment into smaller process modules, the P-4 process allows manufacturing to take place at constant labour and capital productivity over at least a 4:1 ratio of batch sizes. This is a particularly important change in the context of the market for which Multilythics is intended, since a contributory factor to the relatively high costs of hybrid thick film manufacturing has been the difficulty in achieving meaningful automation for small manufacturing runs.
The P-4 assembly process has been tightly integrated with a computer aided design facility so that customers can design their own devices and obtain a manufactured product in a relatively short time.

Dr. G.R. Love is Vice President of Technology, Sprague Electric.

COMPONENT NEWS

New Fresnel lenses

Quantelec has introduced a range of Fresnel lenses for use in intruder detection and security applications. Designed for use with Quantelec's ranges of dual-element pyroelectric IR detectors, there are four different types of lens.



The first lenses to be announced are the Polyfen 24A/3 for use in curved format and the Polyfren 24B for use in flat format. These lenses yield multiple zones (24 in total) including nine main, eight intermediate, five short, and two creep zones. Angular coverage is about 90° for the main zones, 8 m for the intermediate zones, 4 m for short range zones, and 1 to 2 m for creep zones.

Quantelec Ltd • 46 Market Square • WITNEY OX8 6AL • Telephone (0993) 76488.

New component catalogue

A new 282-page catalogue, giving details of the company's extensive range of electromechanical, interconnection, and display products, has been produced by Highland Electronics. Apart from product news, the brochure includes comprehensive selection data and applications information.

Highland Electronics Ltd • Albert Drive • Burgess Hill • BURGESS HILL RH15 9TN • Telephone (0799) 26699.

SEMI optimistic for 1988

Semiconductor Equipment and Materials International (SEMI), the trade association for the semiconductor equipment and materials industry, has predicted a much improved 1988 for its members.

SEMI's data collection programme represents input from more than 200 members around the world. Figures show an escalating backlog, as orders steadily rise and drive a positive book-to-bill that reached 1.18 in the 3rd quarter of 1987, up from 0.91 in the 4th quarter of 1986.

This optimistic attitude was initiated by strong worldwide semiconductor device shipments, reported by the Semiconductor Industry Association (SIA), which topped $3 billion in September last year, up from $2.5 billion for the same month in 1986.

SEMI European Secretariat • CCL House • 59 Fleet Street • LONDON EC4Y 1JU • Telephone 01-353 8807.

Cells and batteries

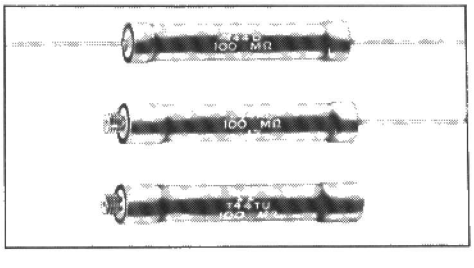
An 8-page full-colour brochure outlining the widest selection of cells and batteries offered by any electronics distributor in the UK has been produced by STC Electronic Services. Products are available from such leading manufacturers as Varta, Duracell, UCAR, Saft, Sonnenschein, Ever/Ready, and Vidor.

The brochure is available free of charge from

The Battery Group • STC Electronic Services • Edinburgh Way • HARLOW CM20 2DF • Telephone (0279) 626777.

High-voltage resistors

A precision high-voltage resistor series that withstands 50 kV DC continuously in air and up to 11 kV when immersed in oil is the latest innovation from the Special Products Devision of Welwyn Resistors, a part of Crystalate Electronics.



The series, coded T40, comprises three types with resistance values in the ranges 1 kohm to 4 Gohm, 15 Gohm, and 45 Gohm. Tolerances of plus or minus five, two, and one per cent, and temperature coefficients of plus or minus 100, 50, or 25 ppm/° C are available.

Welwyn Resistors • BEDLINGTON NE22 7AA • Telephone (0670) 822181.

Capacitor catalogue

AUDIOKITS have announced the most comprehensive catalogue of audio quality capacitors for constructors, service engineers, and audio equipment manufacturers.

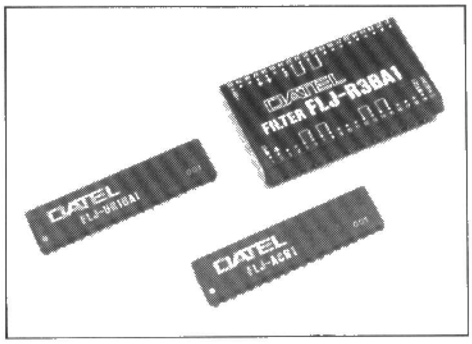
AUDIOKITS' Component Note ACN12 includes detailed specifications, physical dimensions, and prices of many well-known capacitor types, including IAR Wonder Caps, Siderealkaps, and BHC ALS20A reservoir capacitors. Also included are ranges with hard-to-find values and high-voltage ratings.

ACN12 is available to audio constructors at £4.00 incl. postage. A special version, incorporating trade prices of most ranges, is available free of charge to bona fide audio equipment manufacturers and service engineers.

AUDIOKITS Precision Components • 6 Mill Close • BORROWASH DE7 3GU • Telephone (0332) 674929.

Additional component range for Datel

In addition to its present line of data acquisition components, Datel has announced the availability of a complete range of resistor and voltage tuneable filters, digital programmable filters, logic controlled networks, resistor



tuneable oscillators, and oscillator adaptors. The thirty-seven new products are designed to provide front-end filtering and peripheral conditioning for data acquisition systems.

Datel • Intec 2 Business Park • Wade Road • BASINGSTOKE RG24 0NE • Telephone (0256) 469085.

Linear IC Data book

Now available from the House of Power is the Unitrode Linear Integrated Circuits Data Book for 1987-88, a comprehensive guide to the functions and applications of the Unitrode ranges of power, control and interface circuits.

Products covered in the book include power-supply circuits, motion-control circuits, power-driver, and interface circuits.

House of Power • Electron House • Cray Avenue • ORPINGTON BR5 3AN • Telephone (0689) 71531.

8096 proliferation product from Intel

Intel has introduced an 8-bit external bus version of the company's 16-bit 8096 for real-time control applications. The 8098 has the same 16-bit CPU and on-board peripherals as its 8096 counterparts, but with a price of around £3.40, depending on order quantities, the 8098 is half the cost of typical 16-bit devices.

Further information from

Intel Corporation (UK) Ltd • Pipers Way • SWINDON SN3 1RJ.

COMPUTER MANAGEMENT SYSTEMS TAKE OVER

by James Lock

The second half of the 1980s is witnessing the full flowering of fourth generation interactive computer systems, the integration of batch with continuous control, and a trend towards the location of intelligence close to plant of equipment under control.

Several companies in the United Kingdom are investigating the application of expert systems to process control, and software systems such as Auditor from Energy Efficiency Systems[1] are emerging by which plant data can be transferred, via a company's mainframe computer, into accounts and costing systems or into sales forecasting and business planning software.

An important new control system, introduced this year by Ferranti Computer Systems[2], is the PMS 100. Ferranti describes it as an integrated, fully distributed process control and information system for supervisory and direct control, for continuous, sequence and batch control, and for high availability configurations.

It is a far cry from the process plant computer control system installed by Ferranti in 1962 for control of a soda ash plant at ICI's site in Fleetwood. Believed to be the first in the world, that had a program of only 1200 words.

Computing cards of various performance, all based on the Ferranti Argus 700 family of processors, are now used at various locations. Computing power varies from 700 000 inputs per second to more than two million inputs, depending on the configuration.

PMS 100 is a natural development of the first PMS — process management system — installed for the Bayer company at Leverkusen, Federal Germany, in 1975. Over the years, Ferranti technology has been applied in areas ranging from steelworks to radio astronomy.

Making modifications

The data highway, Systembus SB10, is an open system based on international communication standards able to connect to other manufacturers' equipment. In a dual configuration, System SB10 data highways are treated identically. There is no master and no standby, messages are simply transmitted down a free data highway with the advantage of allowing twice the bandwidth in normal operation. A combination of System SB10 and Ferranti's wide area network X.25/F-NET provides a communication capability for any size of PMS 100 network.

PMS 110 is a dedicated process controller that incorporates mixed sequence and continuous control facilities. Normally mounted close to the plant under control, it can be interfaced directly to it or through loop controllers and programmable controllers.

A process engineer can modify and develop new control schemes from either a terminal at the process management information system or on a portable Accessway 110 programmer located, say, in the engineer's office.

The PMS 105 device gateway allows any make of process control or operator device to be integrated into PMS 110, permitting any make of programmable logic controller (PLC) or single loop controller to be specified.

Familiar engineering terms

Batch control in PMS 110 is provided by PMS unit operations, which provides a complete batch control environment for single product, single stream and multi-product multi-stream batch processes. Typical is its use by the Pfizer company for batch processing a range of pharmaceutical processes. A number of batches can be in progress simultaneously through different process steps using the same train of equipment.

The production supervisor can redefine production routes and resources on-line, allowing multi-product manufacture with a minimum of downtime. Automatic batch scheduling permits a campaign to be set up in advance so that production is initiated immediately the plant becomes available and it is also possible to change the order of batches.

Part of the PMS operations software package is Constructor (IPC) which enables the engineer quickly and simply to build up colour graphic process diagrams, graphs and logs. The PMS system's on-line development facility uses a high level programming language which has terms familiar to the engineer and requires no specialist programming expertise.

The trend to put the intelligence of a computer control system in close proximity to the sensors and actuators of a plant rather than relying on a single, central computer is reflected in Newmark Technology's[3] Omnibus range. This stems from the Janus Project, conceived by Professor John Brignell at Southampton University for the application of advanced microprocessor technology to measurement and control.

Omnibus measurement and control systems comprise one or more Omnipoint computers acting as master station/operator interface and a number of Multipoint measurement and control computers distributed over an Omnibus network. The Multipoint units have been developed jointly by Newmark and Jeball, a company formed by Professor Brignell, while the Omnipoint computers are IBM PC or compatible computers in standard or industrial packaging.

Collaborative project

At the heart of the Omnibus concept is a powerful dual processor that implements the synchronous data link communications (SDLC) protocol. To achieve this, Newmark took the Intel Bitbus and enhanced it to handle up to 250 stations over a range of 5 km, from systems that can start with control of a single loop.

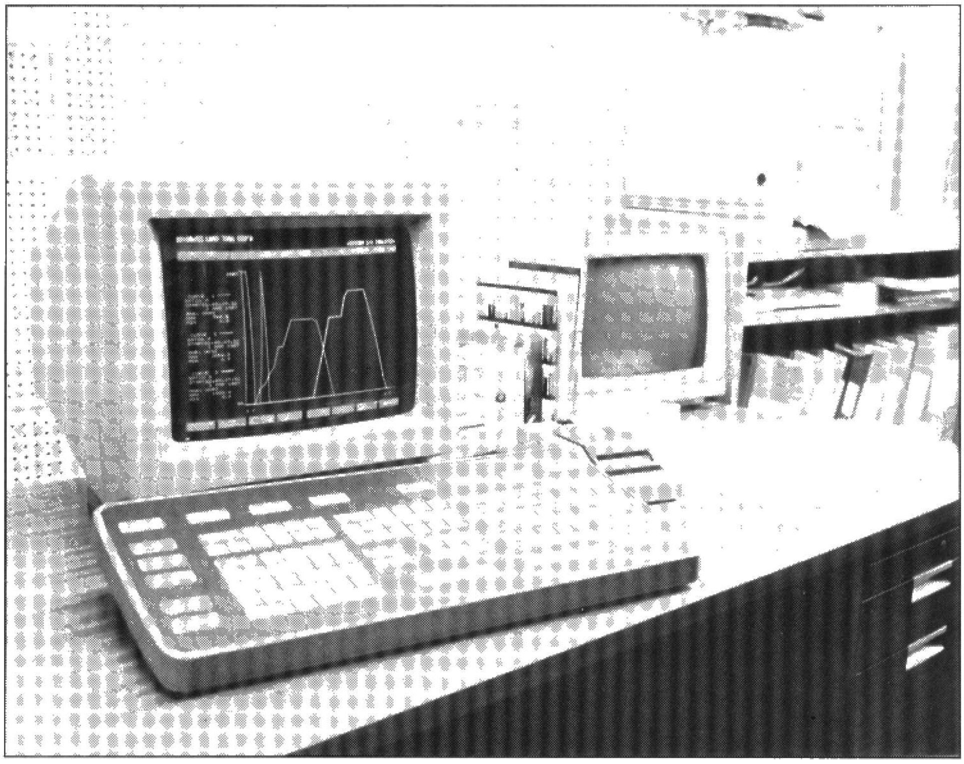
Although a personal computer (PC) is an integral part of the systems loop, the essential difference is that this computer is used simply as a central programmer and data manager rather than as a decision manager.

The majority of decisions made by the system take place at the outstations, removing the problems associated with a failure of the main computer or its communication systems. The use of a plug-in card allows control of the Omnibus network without loading the PC. The

Multipoint units form the remote outstations, each one designed for use in a particular application or environment — the MP100, MP200, MP300, MP400 and now the MP500.

Omnibus communications ensure the compatibility of all Omnipoint and Multipoint units to communicate via a fast multi-drop serial data highway, as welll as Omnibus products from other suppliers. Since Omnibus is Intel Bitbus compatible it is a widely supported fieldbus. Moreover, gateways into the manufacturing automation protocol (MAP), direct from the host PC or via a standard interface on the instrumentation computer board, enable the Omnibus range to communicate through standard protocols in both process and manufacturing industry.

The need to combine the skills of software and process experts has formed the basis of an on-going collaboration between Biotechnology Computer Systems (BCS)[4] and the Department of Chemical and Biochemical Engineering[5] at University College London (UCL) in the development of a comprehensive fermentation management system. BCS is a member of the Porton International group of biotechnology companies that operate worldwide. UCL is one of the British Government's Science and Engineering Research Council (SERC) designated centres for biotechnology. Some 50 staff and researchers are involved and there is collaborative work with some 14 other organizations besides academic institutions and other departments in UCL on various aspects of control.



The new Ferranti PMS 100.

Digital controllers

The first two products are the software packages BIO-i and BIO-pc. BIO-i is a powerful fermentation process management system, BIO-pc is a single user bioprocess management system for up to four reactors with associated on-line equipment.

The design objectives for BIO-i were to produce a single fermentation management system that would satisfy the differing needs of the fermentation plant process engineer and worker, and the research scientist. So BIO-i has been configured as a supervisory system in which distributed digital controllers associated with each fermenter are linked to the process computer. Designed for use with the Digital Systems Equipment range of computers, the package employs well proven programming languages and real time process plant databases. Mass spectrometer data is used in the monitoring of off-gases.

The distributed nature of the system and the ease with which it can be configrued means that new fermenters, sensors and analytical equipment are simply incorporated when they become available.

Fresh results of the collaborative programme, such as the current work on adaptive control, can be added to the package. This has been thoroughly tested on the sophisticated range of termenters and reactors in the UCL pilot plant.

BIO-pc is configured on an IBM-AT or compatible computer, with monitors and other peripherals, and uses the standard MS-DOS 3.1 software package operating system. Its software elements include a complete professional Smart applications package, a feature of which is a spreadsheet with graphics that can be used while the computer is data monitoring and logging the plant.

Short payback time

Kent Process Control Systems[6] has developed integrated configurations of its originally centralised K90 computer process control system, the P4000-ICS. This interesting development, instead of the single or hierarchical configuration of the K90, permits a number of units to be linked via the peripheral highway into one integrated system.

Each peripheral highway, of which there may be more than one per system, has a maximum of eight units, up to four of which may be operator control panels and the rest control processors. The arrangement allows a system to handle different sized process control applications, besides offering a low cost entry to ICS systems. The first two ICS systems have already been supplied to a pharmaceutical company and a major steel producer.

Kent has also introduced an expert system, based on LISP and using a Picon shell, as an option with the P4000 distributed control system. The expert system is designed to simplify interpretation of the volume of data from the process variables being monitored on a medium-to-large system. The volume of incoming data is particularly high during plant changes such as start-up and shut-down procedures.

Several companies are examining the application of expert systems to process control. The first publicised success in the United Kingdom has been LINKman. The Blue Circle cement company, in conjunction with SIRA[7], formerly the Scientific Instrument Research Association, set it up on a KPCS P4000 distributed control system. LINKman succeeded where attempts at more conventional computer process control failed. SIRA has made an agreement with Blue Circle to market the system to other cement producers. Blue Circle has also ordered five complete systems and is anticipating a payback time of six to nine months. This quick return is largely due to energy savings.

Higher level information

In 1984, the Alvey Commission set up a number of expert system demonstration clubs in various industrial sectors. The first of these was in control instrumentation — the Real Time Expert Systems Club of Users (RESCU). The study of an expert system as an adviser on quality control at an ICI company ethoxylates plant for batch production of detergents

has recently been completed.
Systems Designers[8], the contractor for the RESCU club of some 22 members, has now initiated a further club, the Cognitive Systems Club (COGSYS), to convert the results of RESCU into a truly commercial, fully supported product. It is expected to appeal to chemical, food, pharmaceutical and other process industries, the utilities and energy sectors, and the parts manufacture and assembly industries. Members of the COGSYS club will benefit from sales of the completed product and membership is still open to companies and academic institutions.
At the end of 1986, ICI launched Auditor, its plant performance monitoring package, with the support of Britain's Department of Energy and the Chemical Industries Association (CIA). The system, the result of new thinking about the quality of management information in the production sector in the light of reduced fortunes following the oil crises, is now used in more than 60 ICI plants and is being sold to other companies in the chemical and other industrial sectors through Industrial Energy Systems.
Auditor technology is simply a higher layer of production information and it uses existing monitoring devices and information. Linked to the company's mainframe computer system it can transfer data into the accounts and costing system or into sales forecasting and business planning software.
The package also interfaces with two higher level systems developed by ICI. Co-Audinator is designed to monitor and optimise the running of a whole site with several interacting plants, and Energy Management System is used for site or company-wide energy monitoring to allow comparisons of different periods of production with different mixes of product.
Auditor systems installed at ICI have had an average payback time of six months. A standard Auditor package consists of a DEC MicroII computer with a winchester disk, twin floppy disks, one or two display units (normally in colour), and a printer.

1. Energy Efficiency Systems Ltd, Midland House, 202 Linthorpe Road, Middlesbrough, Cleveland, United Kingdom.
2. Ferranti Computer Systems Ltd, Wythenshawe Division, Simonsway, Wythenshawe, Manchester, United Kingdom, M22 5LA.
3. Newmark Technology Ltd, Heathrow Causeway, 152/176 Great South West Road, Hounslow, United Kingdom, TW4 6JS.
4. Biotechnology Computer Systems, Cleveland House, Church Path, Alton Green, Chiswick, London, United Kingdom, W4 5HR.
5. Department of Chemical and Biochemical Engineering, University College London, Gower Street, London, United Kingdom, WC1E 6BT.
6. Kent Process Control Systems, Biscot Road, Luton, United Kingdom, LU3 1AL.
7. SIRA Ltd, South Hill, Chislehurst, Kent, United Kingdom, BR7 5EH.
8. Systems Designers PLC, Centrum House, 101/103 Fleet Road, Fleet, Hampshire, United Kingdom, GU13 8PD.

SECOND GENERATION PROGRAMMABLE LOGIC

by E. Baum

The direct interface system on a microcontroller is, in principle, very similar to that on a microprocessor. In fact, there are slight differences between the individual processor manufacturers, but the applications, i.e. connection of dynamic RAMs, demultiplexing of processor buses or mailbox functions, appear to be very similar. That is why all semiconductor manufacturers offer a range of standard chips which can be connected directly to their own processors. However, there remain many more applications, where these interface modules, or even logics, i.e. latches or other TTL logics, must be added. For this, discrete logics in the 74xxx series are often relied upon. PLAs and EPLDs (erasable programmable logic devices) are also frequently used.
It is now possible to imagine integrating the processor interface and the interface to the controller or processor in a single EPLD. The density of this module of up to 1800 gate equivalents is therefore quite sufficient. However, thanks to the very simple and regular structure of the bus interface, many of these gates remain unused on the chip. This essentially has two disadvantages. Firstly, the chip could be even cheaper if the superfluous gates were totally dispensed with. Secondly, EPLDs and PLAs with large numbers of gates are slower, since the internal capacities are greater and the signal propogation speeds are slower. In some circumstances therefore it is necessary to rely on several small modules.
The new member of the EPLD family from Intel, the 5CBIC (bus interface controller), fills this gap perfectly. As the name implies, this chip offers a highly integrated solution for all designs which contain bus transfer lines or generate control signals. Even the driver, which in some cases still has to be provided in a bus interface, can more often than not be dispensed with when the 5CBIC is implemented. The maximum current on the bus side can be 32 mA. The 5CBIC thus offers all the advantages of high integration such as low space requirement, low current requirement, low system and manufacturing costs, and so on.
Figure 1 shows the basic 5CBIC design. The 8-bit wide A port on the bus management unit, BMU, lies directly on the processor or controller bus. On the ''user side'' there are two further 8-bit ports, B and C. As will be seen later, these three buses are bidirectional and can be combined randomly, even dynamically, with each other. The second largest block is the programmable logic unit, PLU, which contains an 8 macrocell EPLD unit. The PLU has 8 dedicated inputs and 8 bidirectional pins. Both blocks can be supported via the control unit.

Bus Management Unit

The bus management unit links ports A, B and C together and controls and monitors the data flow over their lines. At the same time, the user can choose whether the data flowing into these ports is to be latched or not. For this a latch enable signal can be generated in the PLU or supplied directly via a pin. Various EPROM cells, or dynamically modifiable signals generated by the PLU, control the data flow. Each port can also be connected with any other. Depending on the requirements or the subsequent hardware, the signal can be given out on one of the outputs inverted or directly. Three signals generated in the

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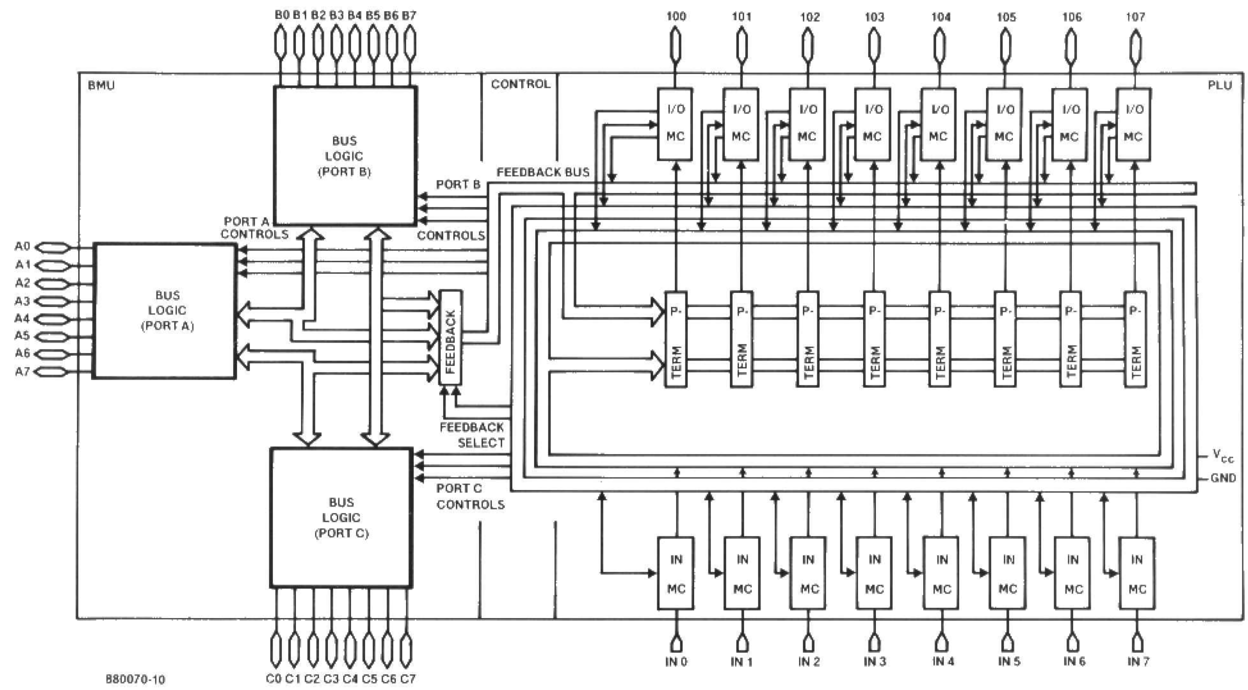

Fig. 1. A Bus Management Unit (BMU) and a 5C060 step-up compatible programmable logic unit (PLU) conventionally connected and manually optimized with the flexibility of programmable logic.

PLU can be sent by the output buffer to the ports in the high resistance state, in order that data may then be received there. A multiplexer can make the signals from a port, latched or not, available to the PLU AND/OR array. The connections between the three ports on the BMU itself, are programmed via EPROM cells (Figure 2).

2

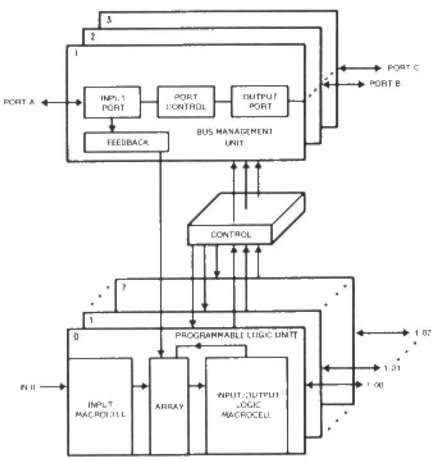

Fig. 2. The data flow can also be configured dynamically.

Consider the connection of the 5CBIC to, for example, an Intel controller in the MCS 51 family. Then, using the BMU, it is possible to demultiplex the address and data bus and make the rest of the circuit available separately on ports B and C. The driver current of 32 mA per pin should be sufficient for most applications. The working frequency of the external logic can be up to 12.5 MHz. Internally, the 5CBIC can work with up to 20 MHz. The PLU can now "observe" the data or address flow and chipselects, generate other control signals or simulate an additional parallel port.

Programmable Logic Unit

The second large block on the 5CBIC chip is the programmable logic unit, PLU. This essentially has a 5C060 EPLD superset. Eight macrocells can, with the help of EPROM cells, be adapted to the application (Figure 3). Eight dedicated input pins and 8 bidirectional pins can be connected to the macrocells. Considering that data from ports A, B or C can also be obtained via the internal feedback bus, the user has up to 24 inputs, and up to 8 outputs available per product term.

As has already been seen with the EPLDs and PLAs logic operations, sequences are firstly converted into an AND/OR structure, which is usually generated and optimized by the development system, IPLDSII (Intel Programmable Logic Development System, version 2). This structure can then be very easily implemented in the AND/OR array on the input of a macrocell as a so-

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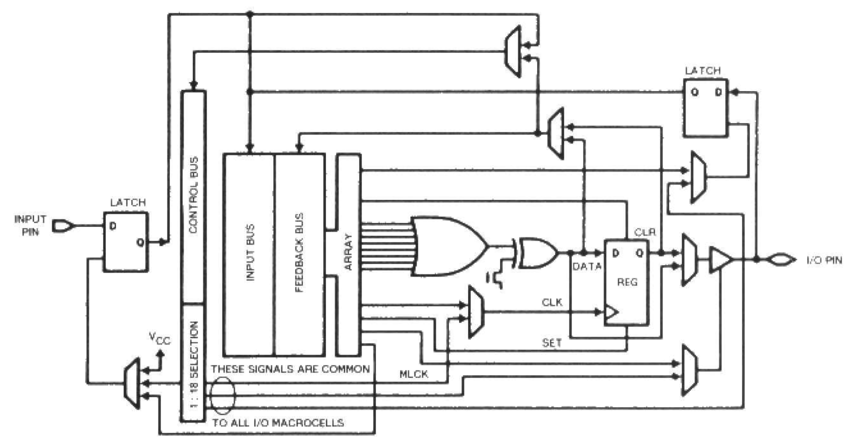


Fig. 3. The 5CBIC macrocells — I/O latches and high driver currents — make the use of the processor bus an optimal application.

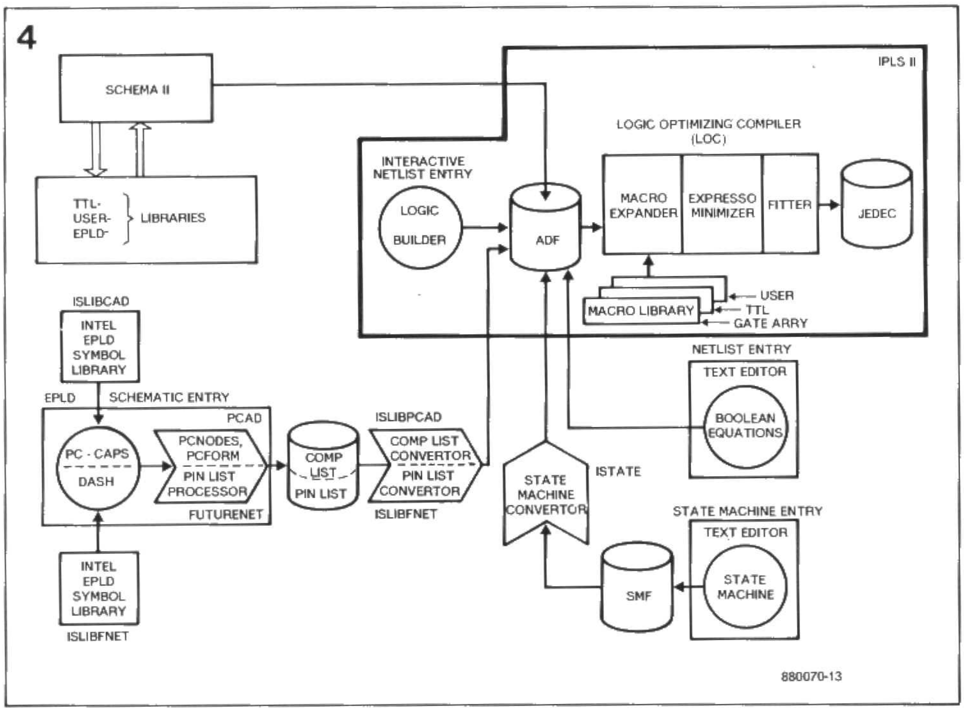


Fig. 4. The IPLDSII allows the use of TTL, gate array, and user-defined symbol libraries.

called sum of products. Each macrocell always has available the 8 dedicated input signals, the 8 macrocell feedback loops, the 8 signals on the bidirectional pins, and the signals on one of the BMU ports. Since all signals are dealt with directly and inverted on the AND/OR array, any combination can be programmed by setting the corresponding EPROM cells. As opposed to the 5C060, each input signal can be individually latched. The only exception are the 8 bits which come from the BMU. These may only be latched together, or not at all. The latch enable signal for each input latch can either be generated individually with the help of a product term or by a common control signal.

Behind the OR gate, which can comprise eight product terms, there is an inverter whose optimum algorithm (Espresso Minimizer) makes life a little easier, since it allows DeMorgan's theorem to be reproduced in the hardware. The consequent I/O section of the macrocell is therefore very like that of the 5C060 (Figure 3). Combinatorial or register logics can be created here. With register logics there is a choice of four registers. Depending on what is most suitable for the application, either a D-, toggle-, JK- or RS-flipflop is used. Whereas when using a D- or toggle-flipflop all eight product terms are connected to one input, with the RS- and JK-flipflops the product terms are shared arbitrarily between both inputs. Each register in the I/O part of a macrocell has a set and a clear input which are controlled via one of its own macrocells.

The clock signal, the latch-enable and the output-enable signals can be individually selected for control between either the control bus (synchronous) or a product term (asynchronous). This also gives greater flexibility in comparison with the macrocells of, for example, the 5C060.

The output of a macrocell can be fed back into the AND/OR array via either the control- or feedback bus. This signal is picked off before the tristate buffer in the cell's output. Behind the buffer, and thus physically linked with the I/O pin, there is a second pick-off. If, therefore, the variable generated by the macrocell is only needed internally, it can be further used as input if the buffer has to be switched to high resistance. Using this dual feedback option, it is very simple to generate the so-called buried registers. The development system keeps these functions transparent for the user.

IPLDSII: expansion of the development system supports the 5CBIC

On many points, the development systems of the EPLDs have been improved with the IPLDSII (Intel Programmable Logic Development System, Version II — Figure 4). The new hardware is now based on the Intel Programmer IUP-PC. Apart from EPLDs, all other EPROM-based modules, EPROM microcontrollers, etc. can also be programmed.

More important though for daily working with EPLDs are the changes in the software. So a new algorithm for optimization (Espresso Minimizer) was implemented. For large EPLDs in particular, important improvements were made in the design density. The fitter, and thus the program part, which assigns a design for optimization of the macrocells in the selected EPLD, has also been improved.

Working with the IPLDSII has also been simplified considerably and made more comfortable. Although previously it was possible to use modular design methods and link together several source files, now it is possible to go even further back to the design macros. The macro-library comprises three blocks:

- TTL macro-library
- Intel Gate Array Library
- User-defined library

The TTL library comprises a collection of the most-used modules in the 74 series. The user enters the modules with the corresponding connections to the remainder of the logic. The macro-expander then converts this information into EPLD primitives which are reunited

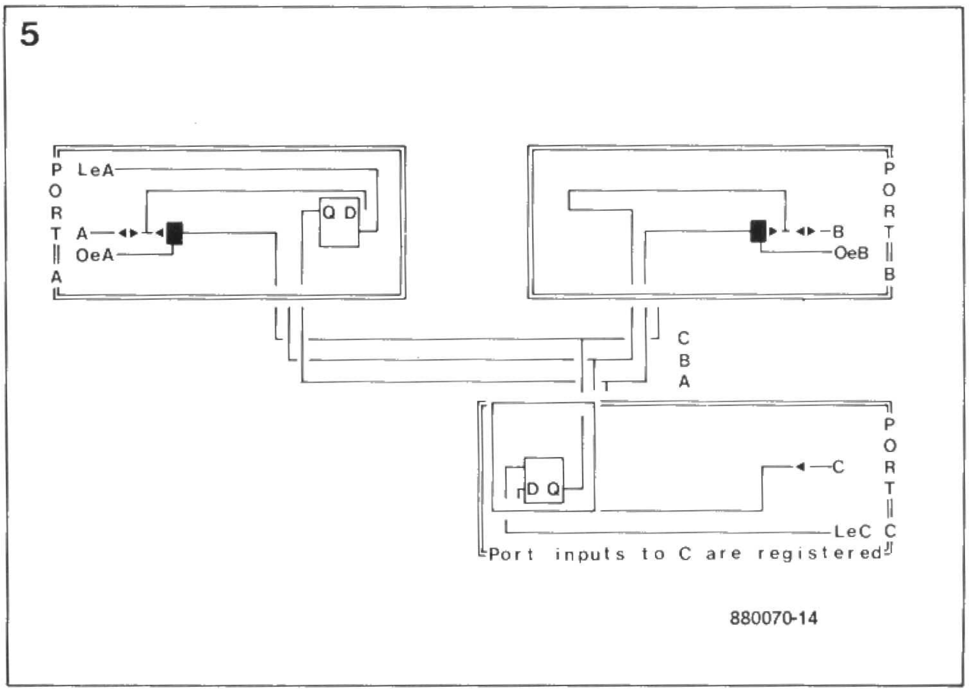


Fig. 5. With the aid of the IPLDSII, the 5CBIC bus management unit can be configured very easily.

in the minimizer. The expander also recognizes if a chip is not being fully utilized and erases the remaining gates. So, for example, if with the 7400 only 2 of the 4 gates are used, only 2 will be implemented in the EPLD.

Sometimes it is possible to use EPLDs as prototypes or backups for a gate array design. In order to make this as simple as possible, Intel has grouped the gate-array macros in a further library, which can be implemented in an EPLD.

Of great interest, of course, is the possibility, with the help of a few utilities, for the user to create a library himself, the elements of which can also be made up of those of the other two, i.e., the TTL library.

As with the old version of the IPLDS, for documentation an advanced design file (Netlist File), a logic equation file with the actually implemented and optimized functions, and a report file with the utilization and pin assignment of the EPLD is generated. If during compiling errors are found, the messages are "collected" in an error file.

In the software output, a JEDEC-compatible file is generated which serves as input variable for one of the programming units, from Intel or another, which support the EPLDs.

The basic version of the IPLDSII supports the circuit input with the help of an editor. It is however simpler to use the logic builder which allows interactive graphically-supported conversion of a circuit diagram into a netlist. The logic builder also makes configuring the 5CBIC bus management unit very simple. A BMU block diagram comes up on the screen (Figure 5). Using the cursor, it is possible to "go into" the desired block, i.e. the block for port C. By simply pressing the "RETURN" key, it is now possible to select from all the configuration possibilities. The respective functionality is entered on the circuit diagram on the screen as are the connections to the other ports. Later the output enable (Oex), latch enable (Lex) or select (Selx) signals are connected. The signals can be connected directly to pins or controlled from one of the macrocells. The compiler takes care of the allocation.

In order to simplify input, various software packages expand the IPLDSII. ISTATE for example allows input of state diagrams and truth tables. Further library and conversion packages allow circuit diagram input using PCAD or DASH.

Since the middle of 1987, Intel has also been offering an IPLDS-compatible software package for circuit diagram input, which is reasonably priced. SCHEMA II, as the package is called, is produced by OMATION and sold by, amongst others, Intel. In addition to their own schematic capture software, some libraries contain EPLD primitives and 74xxx symbols, which can be supported by the IPLDSII. The circuit diagram can now be input and advantage taken of the SCHEMA software, i.e. by plotting on simple EPSON printers or HP LASERJET, and even on plotters working with larger than A4 format. The circuit, which may, of course, contain TTL symbols, is converted into an advanced design file, which then serves as input to the IPLDS compiler. The design is minimized and then fitted into the EPLD selected. In addition to the plot files, the same output files are generated for documentation as when the logic builder is used. In addition SCHEMA II offers a range of other aids. Thus, it is possible for the user to automatically create parts lists, carry out a design rule check, check routing, and print out various data formats, pinlists, netlists, and so on.

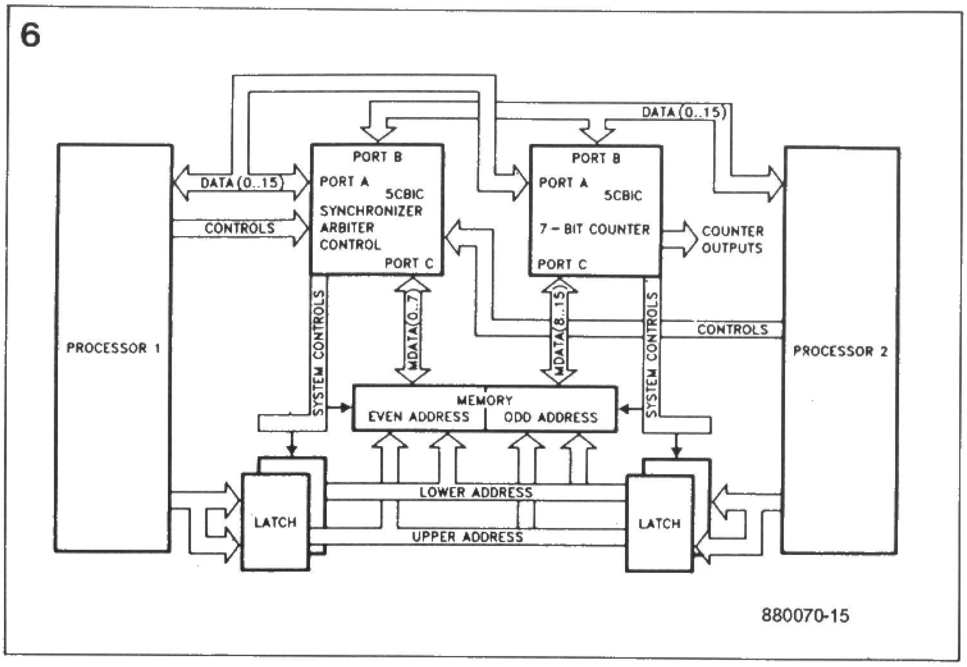


Fig. 6. Two 5CBICs in a 16-bit, twin-processor system carry out the control of the dual-ported RAM.

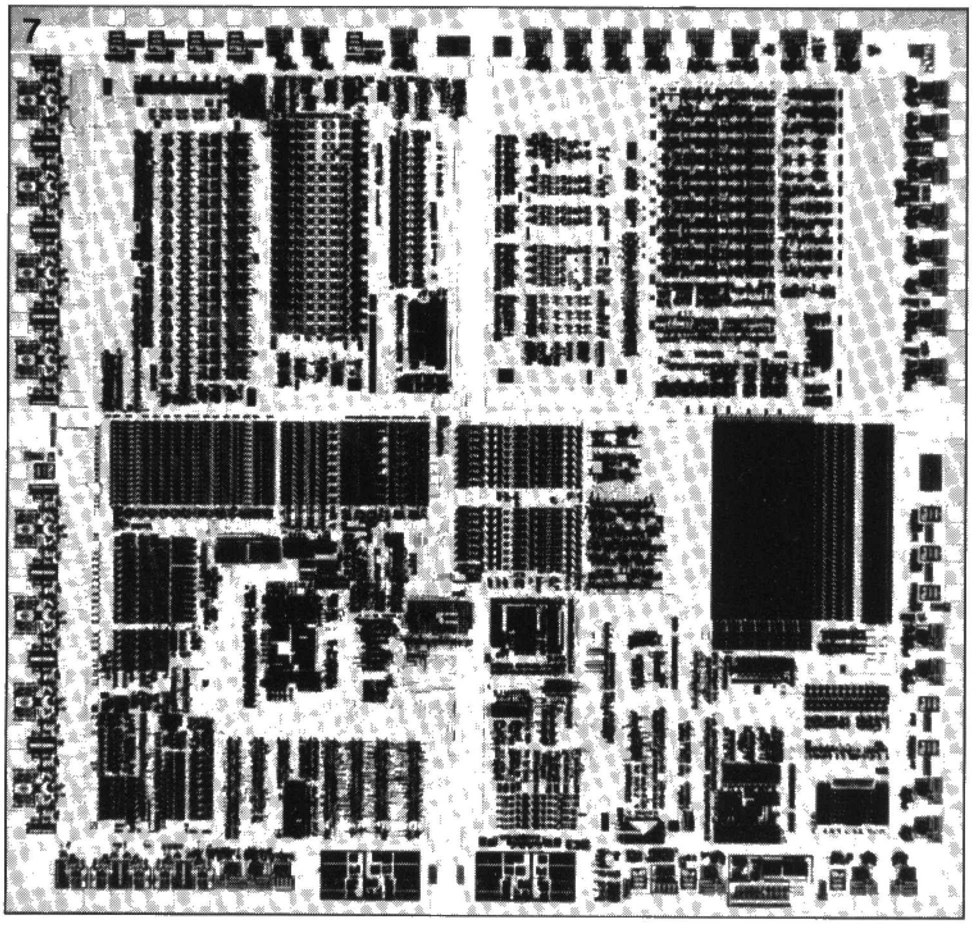


Fig. 7. Photograph of the experimental set-up of Fig. 1.

16 Bit dual port memory

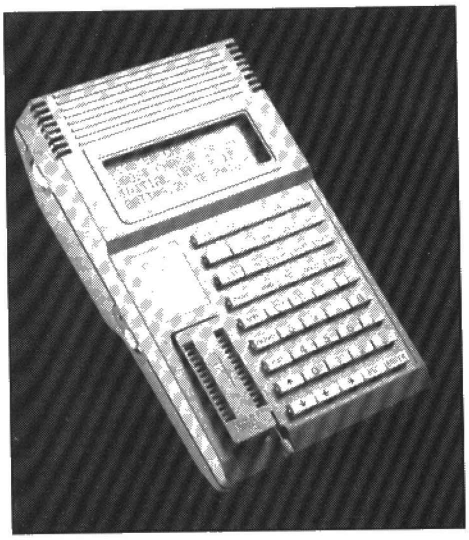
A popular way of making computers faster is to have several processors working in parallel on a single task. Here, the processors must from time to time exchange data for synchronization and management from shared memories. This exchange takes place more often than not via a dual-ported RAM. The logic, which is necessary for managing such a RAM, can now very easily be created with the help of two EPLDs of the 5CBIC type (Figure 6). Here, two 16-bit processors are accepted which can access a joint memory bank. Each 5CBIC can work with an 8-bit width. Two are therefore required. The first module manages the upper 8 bits of the databus. It also takes care of arbitration. The second manages the lower 8 bits. In the PLU, a 8-bit counter is implemented which is required in other parts of the application. Further information is available from Intel in the form of applications leaflets.

Eckart Baum is with Intel, Munich.

COMPUTER NEWS

DATAMAN S3

Dataman's new Intelligent PROM Programmer and Universal Development System, DATAMAN S3, is the next link in the evolutionary chain of tools for microsystem designers, radically different from the big benchtop PROM Programmers.



S3 looks more like a rechargeable calculator than a Prommer. Indeed it is rechargeable, by three hour boost or overnight trickle, and will burn up to 1000 PROMS from its extensive library of EPROMS and EEPROMS without recharging. It's an EMULator too, and will stand in for PROMS up to 27512 size with 100ns access — all 25, 27 28 series in fact, and many others. It isn't just a ROM EMULator: it's a RAM EMULator as well, with a Flying Write Lead to grab the microprocessor's Write line. Variables and Stack can be kept in S3's memory — and inspected and edited there just like the rest of the program. What's more everything is stored in continuous memory and retained even when S3 is turned off.

S3 can be used without touching the keyboard — by two-way RS232 interface with a remote computer via the standard DB25 socket on the back. All the keyboard functions work on the big screen. Assembled code can be downloaded in one of the standard formats at 9600 baud.

The missionary work of introducing S3 has already begun and product is available for immediate delivery. It costs £495, plus VAT. Right now there's a free inspection, 30 day money-back guarantee operating.

Contact DATAMAN, Lombard House, DORCHESTER, Dorset DT1 1RX or phone 0305 68066

Free VMEbus catalogue

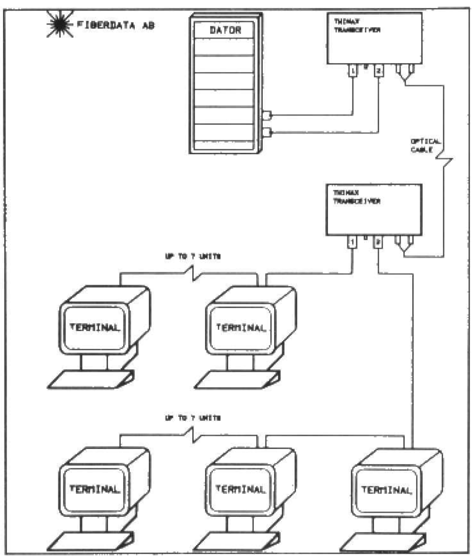
A new catalogue detailing MicroSys' range of VMEbus CPUs, memory and I/O modules is available exclusively in the UK from Dage. Free on request to engineers, the 28-page colour brochure provides shortform details on over 50 VMEbus boards and modules, as well as many other items from cables to boxed systems.

Dage (GB) Ltd • Rabans Lane • AYLESBURY HP19 3RG • Telephone (0296) 393200.

Fibre optic transceiver

Fiberdata AB of Stockholm have designed a fibre optic transceiver that provides noise-free data transfer between IBM S30-series computers and their peripherals.

The transceiver, which provides communication over distances of up to four kilometres, converts electrical data into optical signals and vice versa, so that the data can be transmitted via fibre optic cables.



Tekelec Ltd • Cumberland House • Baxter Avenue • SOUTHEND-ON-SEA SS2 6FA • Telephone (0702) 337337.

DRIVE HEAD CLEANING KIT

National Computer Supplies has extended its range of micro maintenance products with the introduction of the first automatic ¼ inch data cartridge head cleaning kit. Manufactured by Dysan and costing £29 retail, it cleans dirty drive heads in half a minute. Contact

National Computer Supplies • Four Lanes End • Horsley Woodhouse • DERBY DE7 6AY • Telephone (0332) 883333.

First all-CMOS STEbus processor

The first all-CMOS processor board for the STEbus has been announced by British Telecom Microprocessor Systems. Based on Intel's 8031 CPU with CMOS memory and I/O, the board's very low power consumption and inherent noise immunity make it ideally suited to the implementation of computer systems for battery-powered or harsh-environment applications.

British Telecom Microprocessor Systems • Martlesham Heath • IPSWICH IP5 7RE • Telephone (0473) 643101.

STEREO SOUND GENERATOR

A high-quality stereo sound effects board for the Universal I/O bus, based on Valvo's Type SAA1099 advanced single-chip complex waveform generator. Applications include enlivening computer games and operation as a programmable test generator for simulation of composite AF waveforms.

Here is yet another simple to build extension board for the *Elektor Electronics* Universal I/O bus [1]. It answers the popular demand for an advanced sound generator that can be programmed to produce an astoundingly wide variety of complex sounds in stereo, simply by having the computer send the appropriate commands and datawords for each channel via the Universal I/O bus. The main specifications of the sound generator board described here are shown in the shaded box below.

Digital sound

The block diagram of the Type SAA1099 programmable sound generator chip from Valvo (Philips/Mullard) is shown in Fig. 1. The interfacing logic is shown to the left and at the top of the drawing. To the computer, the chip appears as a WOM (write only memory). Reading of the chip status is, however, possible if the processor writes copies of the commands and data into a RAM table for retrieval at a later stage. Input line AØ of the sound generator chip is made high for loading register address bytes, and logic low for databytes. The interface logic on board the SAA1099 latches the register address, obviating the need to repeat this when writing new data to the last selected register. The process of sound generation in the SAA1099 is completely digital, and based on pulse-width modulation.

Table 1 gives an overview of the function assigned to each bit in a particular register. The required octave is programmed separately for each tone generator by writing a 3-bit number in registers 1ØH, 11H and 12H. The frequency range covered within each octave is given in Table 2. The frequency produced, f_o, is determined by the contents of registers Ø8H...ØDH incl., and can be calculated from

$$f_o = \frac{8 \times 10^6}{2^{[17 - O_x + (1 - F_x/255)]}} \quad \text{[Hz]}$$

(consult Table 2 for O_x and F_x).

The contents of registers 14H and 15H determine which signals are passed by the six on-chip mixers. There are four possibilities: (1) all signals are blocked; (2) only the tone is passed; (3) only noise is passed; (4) both the tone and noise are passed. The noise generator clock rate—hence the noise colour—is individually programmable on the left and right channel by writing the appropriate data to register 16H.

Six amplitude controllers can be programmed to set the volume of the generated sound on the stereo output channels. This is effected by writing data to registers ØØH...Ø5H incl. (left: LS nibble; right: MS nibble).

The last programmable section to be discussed is the envelope generator, whose operation is best explained with reference to Table 2 and Fig. 2. In the drawing:

(1) indicates that the output amplitude is determined only by the amplitude controller when the envelope generator is disabled;

(2) indicates that the maximum amplitude is 15/16th of the value set by the amplitude controller when the envelope generator has been enabled;

(3) indicates the moment when a new envelope waveform can be started by reloading EØ and/or E1.

STEREO SOUND GENERATOR BOARD

Features:

- six frequency generators 2048 tones in 8 octaves
- two noise generators
- six tone/noise mixers
- six stereo amplitude controllers
- two stereo envelope generators
- stereo six-channel output mixer
- on-board 2×200 mW AF amplifier

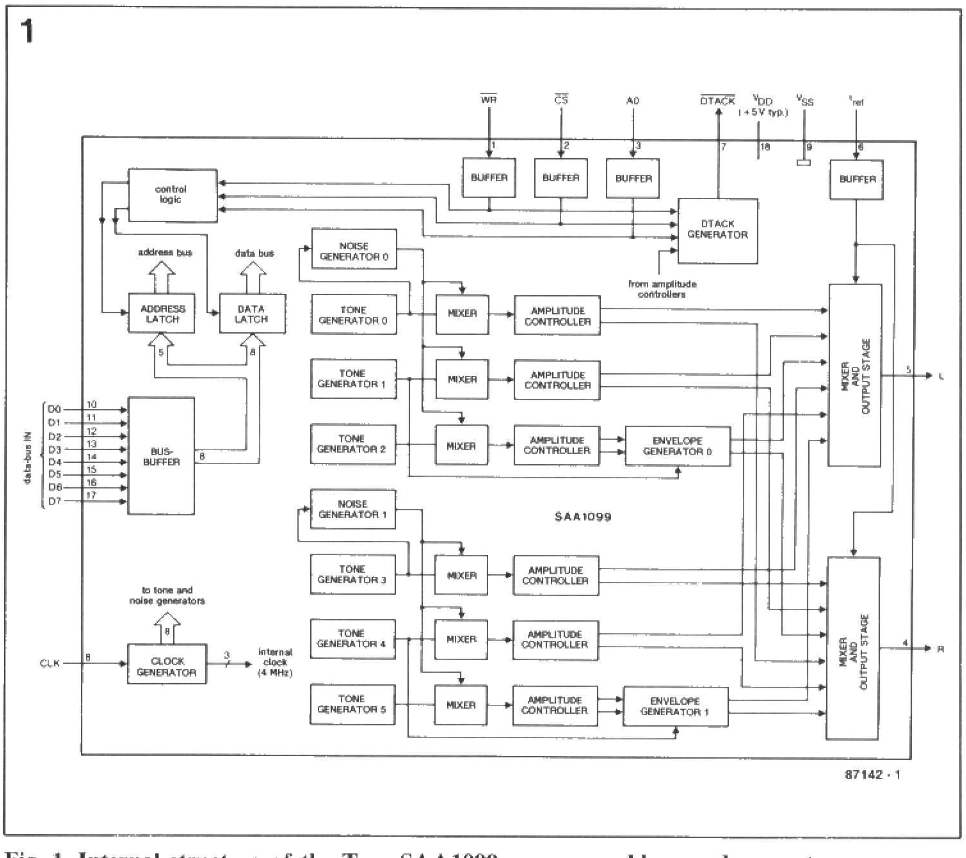


Fig. 1. Internal structure of the Type SAA1099 programmable sound generator.

Table 1.

INTERNAL REGISTER MAP									
register addres	data D7	D6	D5	D4	D3	D2	D1	D0	Function
00	AR0				AL0				Amplitude 0, right/left
01	AR1				AL1				Amplitude 1, right/left
02	AR2				AL2				Amplitude 2, right/left
03	AR3				AL3				Amplitude 3, right/left
04	AR4				AL4				Amplitude 4, right/left
05	AR5				AL5				Amplitude 5, right/left
06	00								
07	00								
08	F0								Frequency 0
09	F1								Frequency 1
0A	F2								Frequency 2
0B	F3								Frequency 3
0C	F4								Frequency 4
0D	F5								Frequency 5
0E	00								
0F	00								
10	0	O1			0	O0			Octave 1: Octave 0
11	0	O3			0	O2			Octave 3: Octave 2
12	0	O5			0	O4			Octave 5: Octave 4
13	00								
14	0	0	FE5	FE4	FE3	FE2	FE1	FE0	Frequency Enable
15	0	0	NE5	NE4	NE3	NE2	NE1	NE0	Noise Enable
16			N1				N0		Noise generator 1; Noise generator 0
17	00								
18	E0								Envelope generator 0
19	E1								Envelope generator 1
1A	00								
1B	00								
1C	0	0	0	0	0	0	0	SE	Sound Enable
1D	00								
1E	00								
1F	00								

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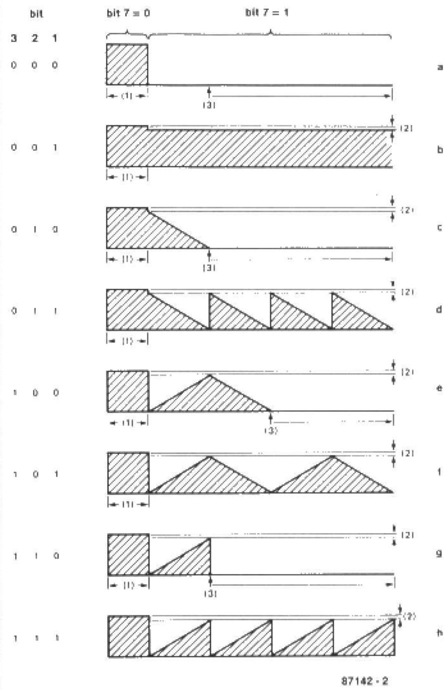


Fig. 2. Programmable envelope waveform shapes.

The letters in brackets to the right of the envelope waveforms in Fig. 2 refer to the bit combinations in Table 2 (E0-E1; bit 1, 2, 3).

When the envelope mode is selected for a channel, the amplitude of the associated amplitude-controller is rounded down to the nearest even value (the LS bit is considered low). If, for example, the volume was set to value 1, it is rounded down to 0. An envelope generator can also function as a tone generator. If the controlled frequency channel is inactive (tone & noise generator turned off), the programmed envelope wavevorm will appear at the output. In this way, the sound generator board can function as a programmable waveform generator with a maximum output frequency of about 1 kHz. Faster envelope waveforms can be achieved by reducing the resolution of the envelope from 4 to 3 bits (bit 5 of byte E0 or E1). The speed of the envelope is determined by frequency generator 1 (or 4), or by the computer repeatedly writing to the address latch, clocking the envelope generator with the $\overline{\text{WRITE}}$ signal ($\overline{\text{WS}}$). The period of the envelope, t_e, is calculated from

$$t_e = 8/f_{clock}$$

in the 4-bit mode, or

$$t_e = 4/f_{clock}$$

in the 3-bit mode.

Bit SE (sound enable) can be used for turning the sound generator on and off. The programming of sounds is largely a matter of trial and error establishing of the required bit patterns, writing data to the chip, listening to the resultant sound, debugging the data and register selections, and making the required modifications.

Circuit description and construction

The sound generator board is composed of relatively few parts—see the circuit diagram of Fig. 3. The $\overline{\text{WR}}$ signal for the SAA1099 is made by combining R/$\overline{\text{W}}$ and Φ2 in gates N_1 and N_2. The crystal-controlled oscillator built around T_1 and T_2 provides the 8 MHz clock signal for the sound generator chip.

The pulse-width modulated output signals of the SAA1099 are converted to analogue in R-C filters composed of $R_4 \ldots R_7$ incl. and $C_3 \ldots C_8$ incl. Integrated stereo output power amplifier IC_1 can provide about 2×200 mW to the loudspeakers.

Construction of the board is straightforward, and requires no further detailing. Supply power for the sound generator board may be obtained from the computer. Due attention should be paid to adequate decoupling, however: in some cases, interference on the supply lines from the computer will necessitate feeding the board from a separate, regulated, 5 V supply (cut off pins 1 and 2 at the board side of edge connector K_1).

Control software

Control programs for the sound generator board should be written with ease of register operations in mind. A simple, yet effective, way of achieving access to the registers and their contents is to

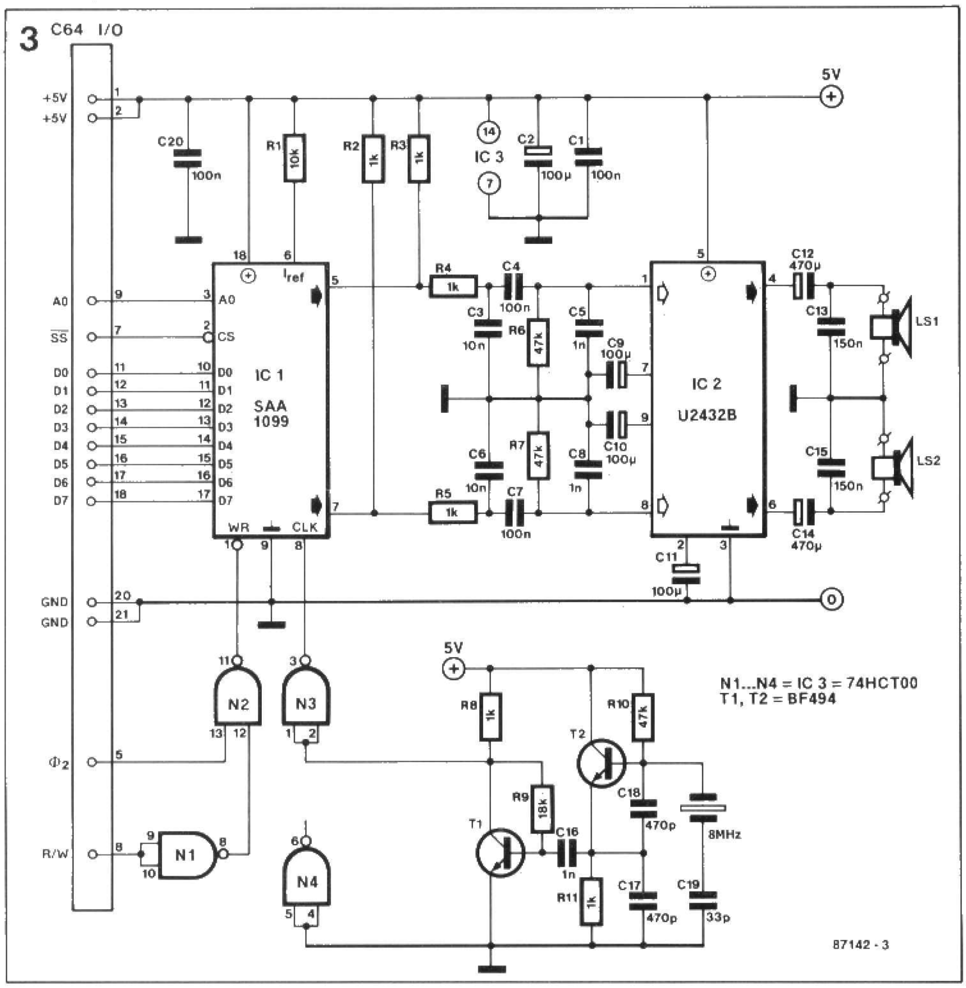


Fig. 3. Circuit diagram of the stereo sound generator board.

This array is set up to enable the computer to keep track of the data written to the registers in the interface. Next, all registers in the SAA1099, and array "register", are reset to nought in a FOR-NEXT loop. The program then enters a infinite loop for fetching register selection codes and data from the keyboard, and transferring these to the SAA1099 via the Universal I/O bus. First, the register contents are displayed on screen, so that the status of all registers is known at any time. Consecutive INPUT statements then prompt the user to enter the register address, and associated data. The program then updates the contents of array "register", and, of course, that of the addressed register. It then returns to the loop entry point.

Finally, here are two examples of sounds that can be generated by the sound effects board:

Steam locomotive: set AR2 and AL2 to an arbitrary value greater than 1. Set NE2=1; NØ=Ø; EØ=4. Bits and bytes not mentioned are set to nought, except, of course, the sound enable bit.

Bell: set the volume as required (AR2 and AL2). Set F2=FFH, O2=7; FE1=1; FE2=1; EØ=4 and SE=1. Bits and bytes not mentioned are set to nought. *St*

Reference:

(1) Universal I/O bus. *Elektor Electronics* May 1985, p. 35 ff.

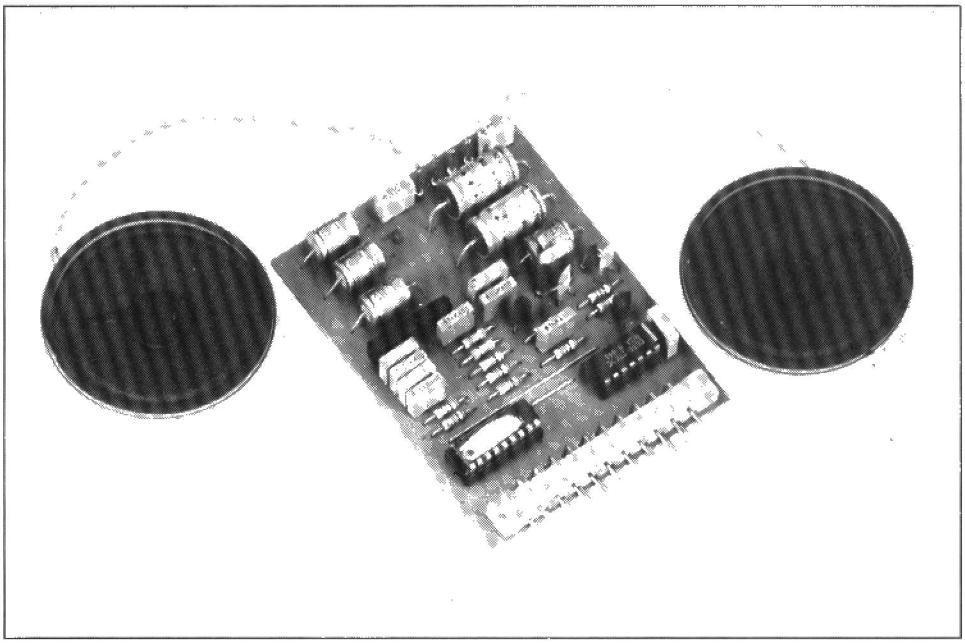
5

```
start
REM initialization
DIM register (31)
FOR N=0 TO 31
    POKE addres-latch, N
    POKE data-latch, 0
    register(N) : =0
NEXT N

REM initialization complete
REM start experimenting

loop
    clear screen
    REM print register contents
    FOR N=0 TO 31
        PRINT N;register(N)
    NEXT N

    INPUT "addres",addres
    INPUT "data",data
    register(addres) : =data
    POKE addres-latch, addres
    POKE data-latch, data
go to loop
```

Fig. 5. Suggested structure of a control program for the sound generator board.

make use of a register selection subroutine, in conjunction with data statements and arrays. Also, do not forget to copy data written to the registers in reserved memory areas of the computer.

The program structure shown in Fig. 5 is intended as a guide for writing one's own control programs for the sound generator board. The program starts by dimensioning array variable "register".



Completed prototype of the stereo sound effects generator for the Universal I/O bus.

Table 2.

	REGISTER DESCRIPTION
ARx, ALx	4 bits for amplitude control of generator x, left and right channel.
Fx	8 bits for frequency control of generator x in designated octave.
Ox	3 bits for octave control of generator x. 000 lowest octave 30...60 Hz 001 50...122 Hz 010 122...244 Hz 011 244...488 Hz 100 489...977 Hz 101 978...1950 Hz 110 1.95...3.90 kHz 111 highest octave 3.91...7.81 kHz
FEx	1 bit FEx = 0 indicates that generator x is off. FEx = 1 indicates that generator x is on.
NEx	1 bit NEx = 0 indicates that mixer x does not add noise. NEx = 1 indicates that mixer x adds noise.
N1, N2	2 bits for noise generator control. These bits select the clock rate of the noise generator. 00 31.3 kHz 01 15.6 kHz 10 7.6 kHz 11 51 Hz to 15.6 kHz (frequency generator 0/3)
E0, E1	7 bits for envelope control. bit 0 0 = left and right component have the same envelope. 1 = right component has inverse envelope of that applied to left component. bit 1,2,3 000 zero amplitude (a) 001 maximum amplitude (b) 010 single decay (c) 011 repetitive decay (d) waveforms are 100 single triangular (e) illustrated in Fig. 2. 101 repetitive decay (f) 110 single attack (g) 111 repetitive attack (h) bit 4 0 = 4 bits for envelope control (f_{max} = 977 Hz). 1 = 3 bits for envelope control (f_{max} = 1.95 kHz). bit 5 0 = internal envelope clock (frequency generator 1 or 4). 1 = external envelope clock (address write pulse). bit 6 must be 0. bit 7 0 = reset (no envelope control). 1 = envelope control enabled.
SE	0 = all channels disabled. 1 = all channels enabled.

Parts list

Resistors (±5%):

R_1 = 10K
R_2...R_5 incl.;R_8;R_{11} = 1K0
R_6;R_7;R_{10} = 47K
R_9 = 18K

Capacitors:

C_1;C_4;C_7;C_{20} = 100n
C_3;C_6 = 10n
C_2;C_9;C_{10};C_{11} = 100μ; 6 V
C_5;C_8;C_{16} = 1n0
C_{12};C_{14} = 470μ; 6 V
C_{13};C_{15} = 150n
C_{17};C_{18} = 470p
C_{19} = 33p

Semiconductors:

T_1;T_2 = BF494 (Cricklewood Electronics)
IC_1 = SAA1099 (CSI Electronics)
IC_2 = U2432B (AEG-Telefunken; Cirkit)
IC_3 = 74HCT00

Miscellaneous:

X_1 = quartz crystal 8 MHz.
K_1 = 21-way right-angled plug to DIN41617 (stock no. 471-418: Electromail 0536 204555).
LS_1;LS_2 = miniature loudspeaker: 8 Ω; 250 mW.
PCB Type 87142 (see Readers Services page).

4

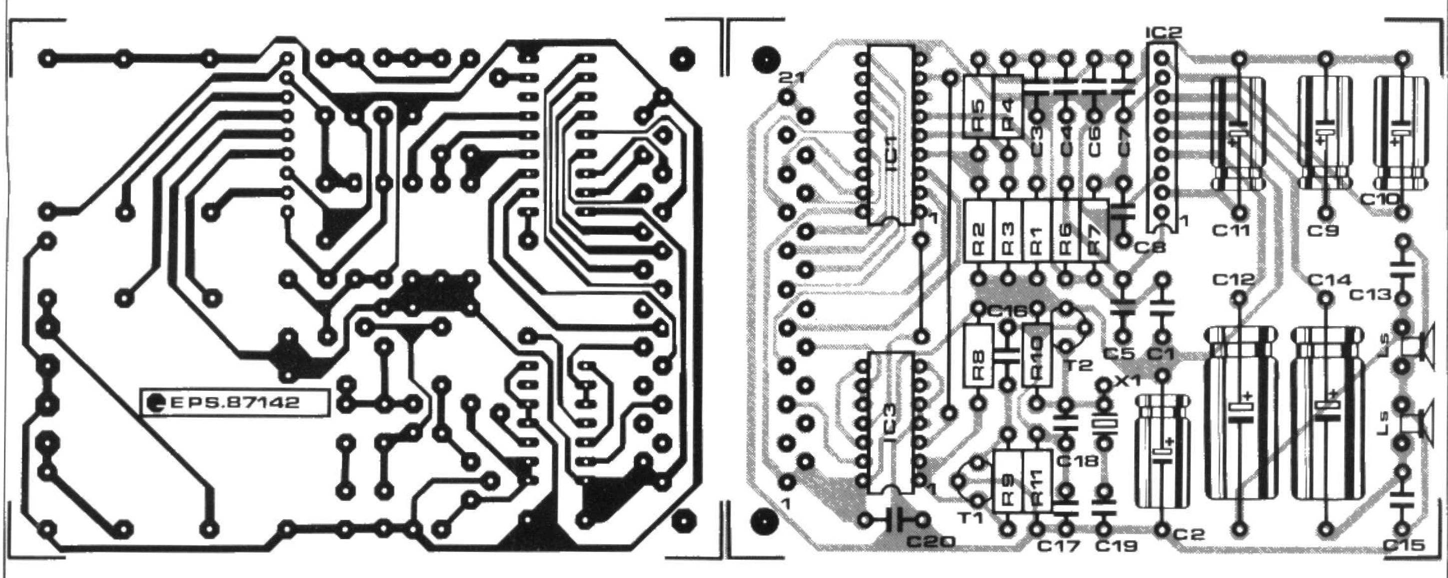


Fig. 4. Printed circuit board for building the stereo sound generator.

DESIGN IDEAS

The contents of this column are based solely on information supplied by the author and do not imply practical experience by *Elektor Electronics.*

COMPUTER CONTROLLED MUSIC GENERATOR

by Dr B. Koyuncu, Department of Physics, Kuwait University

The design of a generator is described, which is operated via a computer to control NOTE, OCTAVE, and VOLUME. It simulates a 14-key piano with the computer keyboard acting as that of the piano. BASIC programming is used for operation and storing the music for playing at a later stage.

The musical piece is coded in binary form with the aid of a BBC personal computer. The information on the data lines is fed into the circuit through the computer's user port. There are three controls: VOLUME, OCTAVE, and NOTE. The system is shown diagrammatically in Fig. 1.
The system generates the whole tones (white notes = naturals on the piano) of the first two octaves above middle C. Fourteen notes are thus available spanning a frequency range of 263 Hz to 992 Hz. Music is generated either manually by manipulating the keyboard or automatically from the computer memory.

System description

Six computer data lines are used from the output port. Since seven notes are available in each octave (*doh*, *ray*, *me*, *fah*, *soh*, *lah*, *te*), three lines are allocated for note control. These lines represent the binary variations 001-111: each code represents a note.
Two octaves (the first and second above middle C) are available and one data line is used for their control. A 1 on the data line represents the first octave, and a 0, the second octave, above middle C.
The last two lines are used to control the volume. Since there are four possible states (00-11), four volume levels are available in the circuit. Each data line is input to a one-bit register. A 6-bit parallel-in register is used to transfer data from the computer.
A 3-to-8 decoder decodes the relevant register outputs to generate the frequencies corresponding to the seven white notes. No decoder is necessary for the two octave control. Since four volume levels are available, a 2-to-4 decoder is allocated to provide these from the two data lines.

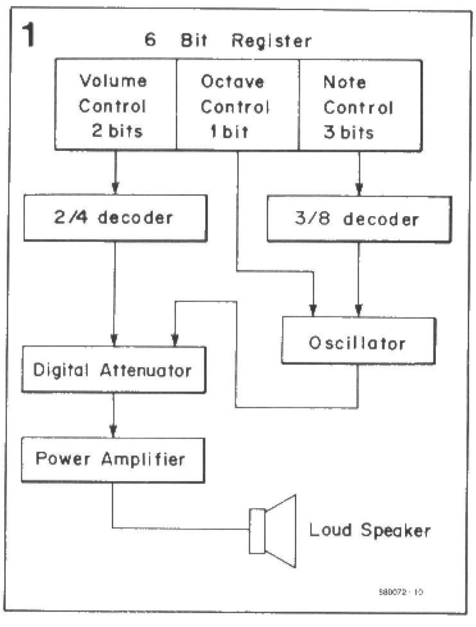


Fig. 1. Block diagram of the circuit.

Decoder outputs for note control and the single octave control signal (high or low) are fed into a Wien bridge oscillator. Volume control is introduced on the oscillator output via an attenuator: 2-to-4 decoder outputs are used as relay control lines to include discrete attenuation levels to the oscillator output.
One of the important effects associated with the musical notes and octaves is the generation of sine waves at different frequencies and amplitudes. These sine waves are generated by the oscillator when the relevant computer keys are pressed: the sound is obtained from a loudspeaker via a power amplifier.
Each octave contains 12 notes: 7 white and 5 black (at least on the piano). On a piano, the white notes are:

C; D; E; F; G; A; B

while the black notes are:

C#; D#; F#; G#; A#

The standard musical note is A and its frequency is 440 Hz. In the *diatonic* scale, the ratios between whole notes are:

C:D = 9:8
D:E = 10:9
E:F = 16:15
F:G = 9:8
G:A = 10:9
A:B = 9:8

Since standard A = 440 Hz, the C below it (middle C) =

$9/10 \times 8/9 \times 15/16 \times 9/10 \times 8/9 \times 440 =$ 264 Hz.

Since in the diatonic scale the ratio between different successive notes varies, it is difficult to tune a keyed instrument to the diatonic scale.
This difficulty is obviated by using the *chromatic* scale, in which the ratio between the frequencies of successive ascending notes is a constant ($2^{1/12}$ = 1.059463). The ratio for descending successive notes is 0.943874. The ratio between similar notes in successive ascending octaves is 2; in successive ascending octaves 1/2: these ratios are the same as in the diatonic scale.
In the present design, the lowest generated frequency is taken as the middle C, i.e., 261.63 Hz. The other 13 frequencies are: 293.66; 329.63 . . . 880; 987.77 Hz (these can also be ascertained from Table 1).
Each of these frequencies is generated by a separate Wien bridge oscillator, diagrammatically shown in Fig. 2. In the coupling network associated with this type of oscillator, it is convenient, but not essential, to make the resistances and capacitances equal. The ratio V/e (= gain) is given by

$$V/e = R/(3R + j\omega CR^2 - 1/j\omega C) \qquad [1]$$

For zero phase shift, $\omega^2C^2R^2 = 1$. Since the frequency, $f = 1/2\pi RC$, the value of V/e becomes 3. Thus, in its simplest form, this type of oscillator has a gain of 3 and the phase shift is zero. Oscillation will be maintained at a frequency which gives zero phase shift between the signals at points A and B in Fig. 2.

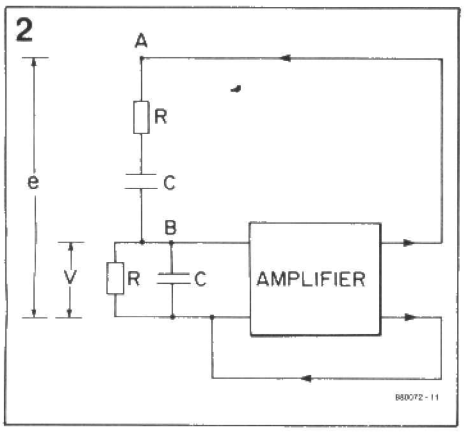


Fig. 2. Simplest form of oscillator.

The practical circuit must be modified to allow for amplitude stability, and this is provided by thermistor R_{Th}. The resistance of this component decreases when the power dissipation rises. The average output voltage available from the oscillator is 1 V_{rms}. The optimum value of the thermistor is about 1 kΩ. This means that only 1 mW of power is dissipated: consequently, the variation in resistance is very small. So, the circuit has to be able to produce a relatively large change in voltage for a small variation of resistance. Therefore, the thermistor and Wien network are combined into a bridge circuit as shown in Fig. 3. Oscillations are maintained by increasing the gain of the amplifier to a level which is just sufficient to overcome the attenuation of the network. If, for any reason, the output voltage increases, the resistance of R_{Th} decreases, the total attenuation will approach 3, and this will reduce the voltage fed to the amplifier. Ideally, while the total phase shift must remain zero, the amplification must be high so that points A and A' in Fig. 3 have approximately equal potentials.

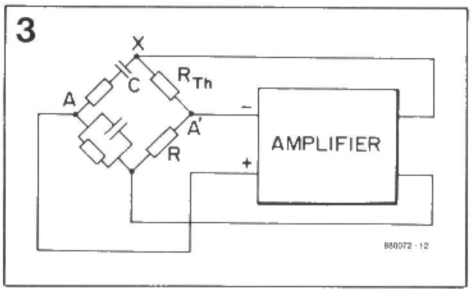


Fig. 3. Simple oscillator with bridge network.

Design procedure

D-type, positive-edge triggered, flip-flops are used to store the on-line data coming from the computer. In addition, data coming from the output section of the user port is already stored in the serial register of this port.
The relevant output lines are connected to the circuit via three-state buffers. When the control line of a buffer is active, the input to the buffer is passed to its output; otherwise, the input is isolated and the output will be high impedance.
Two sets of buffers are used to switch between computer and manual operation. The inputs for one set are coming from the user port, while those for the other set are coming from the manual switches. One set of buffers has an active low control line, whereas that for the other set is active high. The levels on

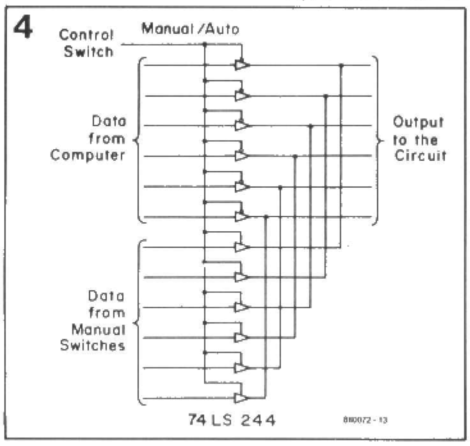


Fig. 4. Computer/manual operation by two sets of three-state buffers.

these lines are controlled by mechanical switches. The switching arrangement is shown in Fig. 4.
Information stored temporarily in the register is decoded by the 3-to-8 and 2-to-4 decoders. The 3-to-8 decoder has three inputs which give seven output codes, 001-111. Any particular 3-bit input code produces a low level at the relevant decoder output and a high level at all the other outputs. Each decoder output corresponds to a particular oscillator signal

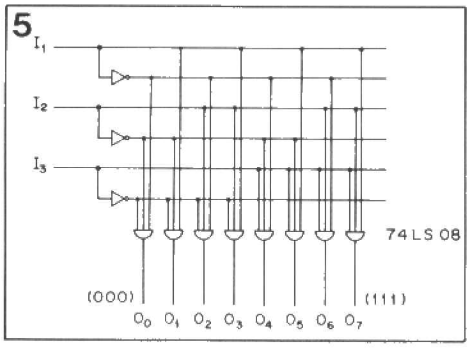


Fig. 5. 3-to-8 logic decoder.

and is used to actuate a magnetic relay. The 2-to-4 decoder is similar to the 3-to-8 circuit, but has only four outputs. Each output represents a volume level. This is effected by the output actuating a magnetic relay that introduces a given attenuation onto the oscillator output.
The decoders are constructed from AND gates and inverters as shown in Fig. 5 (illustrated is the 3-to-8 decoder).

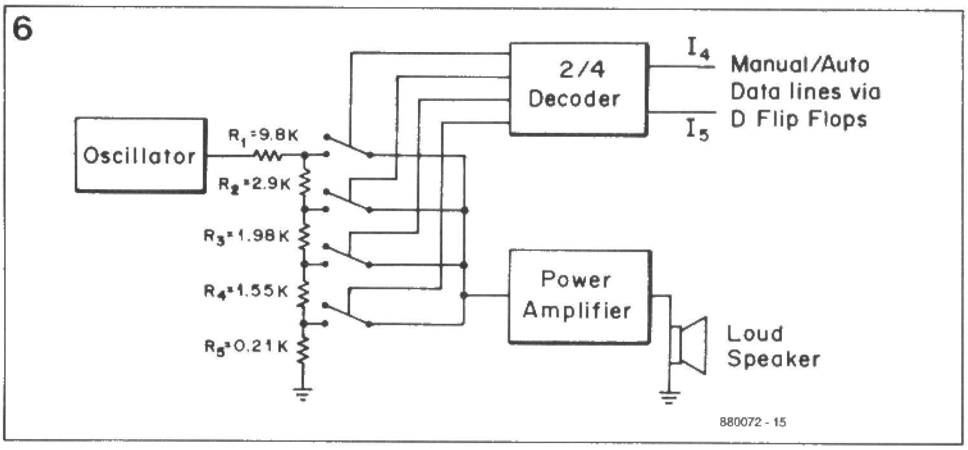


Fig. 6. Digital attenuator.

Table 1.

Frequencies in Hz of the chromatic scale over eight consecutive octaves.

octaves \ tone	C	C#	D	D#	E	F	F#	G	G#	A	A#	B
+4	4186.00	4434.91	4698.62	4978.02	5274.05	5587.64	5919.90	6271.91	6644.86	7039.99	7458.60	7902.12
+3	2093.00	2217.46	2349.31	2489.01	2637.00	2793.80	2959.93	3136.00	3322.48	3520.00	3729.31	3951.10
+2	1046.50	1108.73	1174.70	1244.55	1318.50	1396.90	1479.96	1568.00	1661.24	1760.00	1864.66	1975.50
+1	523.25	554.36	587.33	622.25	659.26	698.46	740.00	784.00	830.61	880.00	932.33	987.77
0	261.63	277.19	293.66	311.12	329.63	349.23	370.00	392.00	415.31	440.00	466.16	493.88
−1	130.81	138.59	146.83	155.56	164.81	174.61	185.00	196.00	207.65	220.00	233.08	246.94
−2	65.41	69.30	73.42	77.79	82.41	87.31	92.50	98.00	103.83	110.00	116.54	123.47
−3	32.70	34.64	36.71	38.89	41.20	43.65	46.25	49.00	51.91	55.00	58.27	61.74

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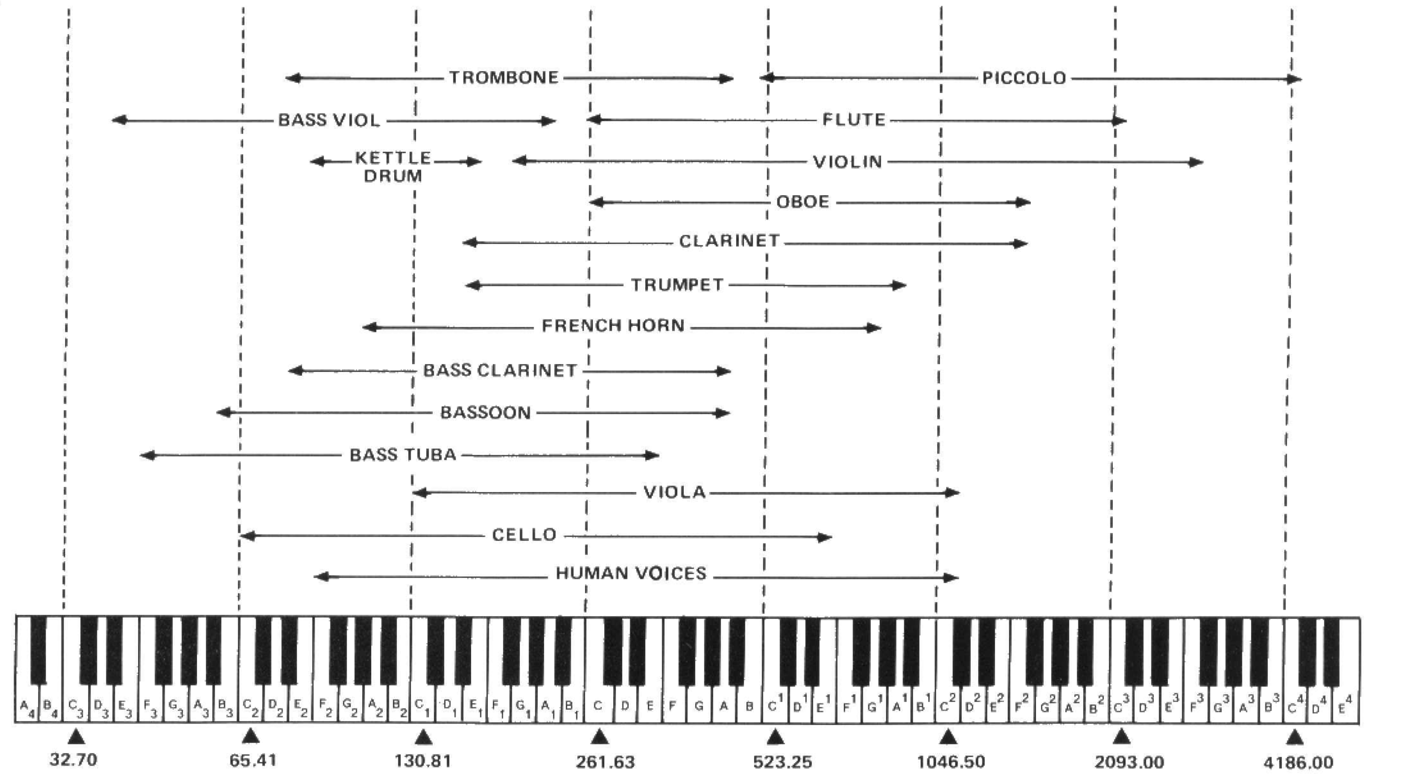

Fig. 7. Correlation between piano keys, notes, octaves, and frequencies.

The oscillator output is connected to the 2-to-4 decoder and power amplifier via a switched attenuator network as shown in Fig. 6. When a particular volume level has been selected, the corresponding 2-bit code is fed to the decoder. The appropriate decoder output becomes active and closes a specific magnetic relay. Consequently, the oscillator output is subjected to a measure of attenuation before it is applied to the power amplifier.

The Wien bridge oscillator contains *R-C* combinations that determine the notes and octaves. Each note-octave combination represents a frequency and this is varied by changing the value of the capacitance (octaves) or that of the resistors (notes).

For instance, frequency f_1 of the octave above middle C (treble stave) is $f_1 = 1/2\pi R_1 C_1$, while frequency f_2 of the same octave is $f_2 = 1/2\pi R_2 C_1$. So, $f_1/f_2 = R_2/R_1$ (and also $= 1/2^{1/12}$).

Therefore, $R_2 = R_1/2^{1/12}$, $R_3 = R_1/2^{2/12}$, $\ldots R_7 = R_1/2^{6/12}$. If R_1 is given a value of, say, 20 kΩ, the others can be calculated from the above equations.

Capacitance C_1 for the octave above middle C is calculated as 0.03 μF for f_1 = middle C = 261.63 Hz and R_1 = 20 kΩ. For notes in the 2nd octave above middle C, the value of the capacitance is halved, so that $C_2 = 0.015$ μF.

The various resistors and capacitors are connected to the relevant relays as shown in Fig. 8. The control lines of the relays connecting each pair of equal resistors are joined together to the outputs of the note control decoder. The same technique is used for the capacitors.

The relays connect two resistors and two capacitors simultaneously into the bidge circuit to activate the oscillator. The result is one of the 14 available notes at the output. A general layout of this arrangement is given in Fig. 9.

Manual operation is provided by means

8

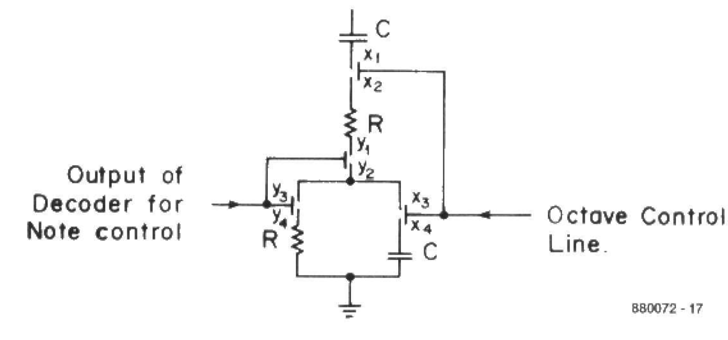

Fig. 8. Connections between coupling network and relays.

9

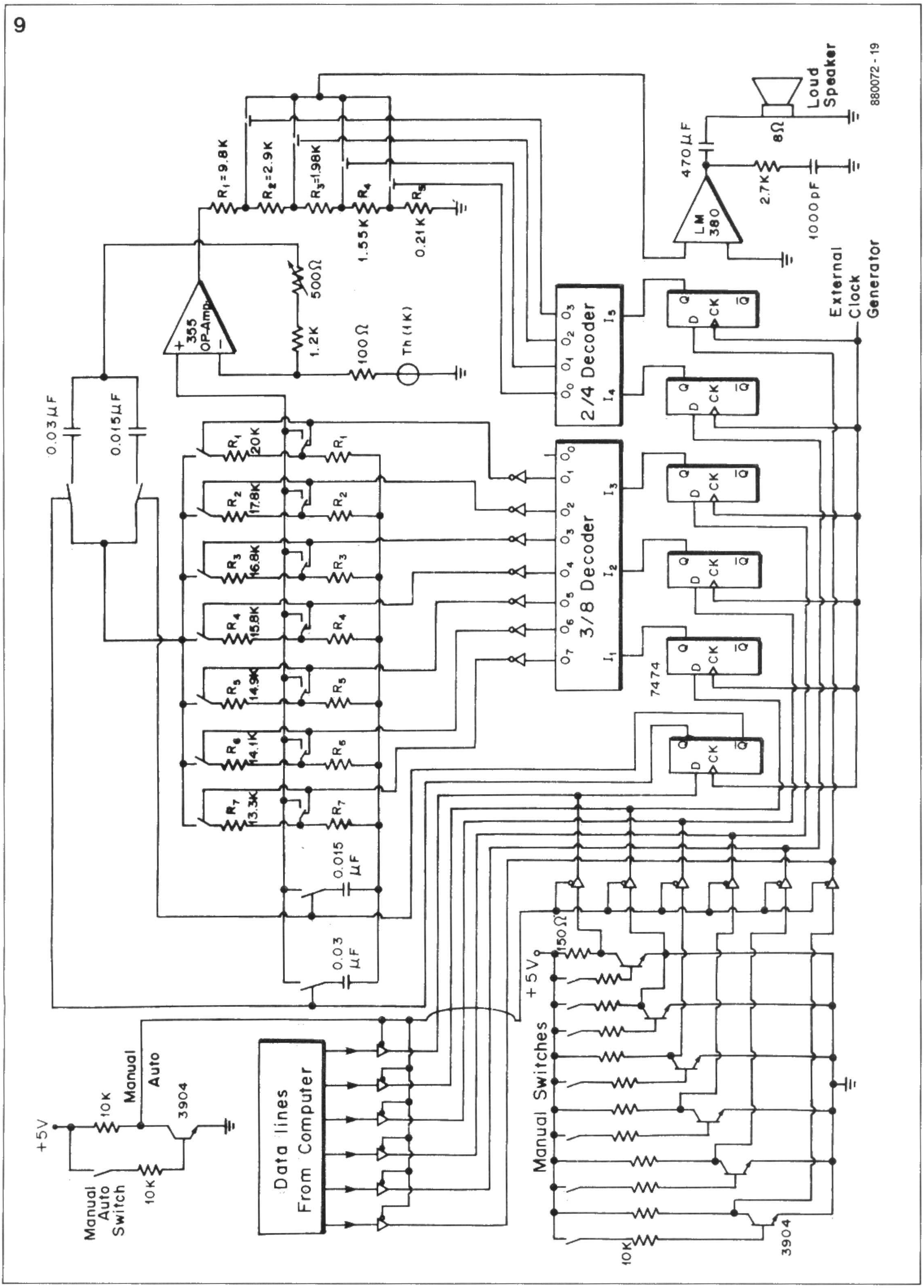

Fig. 9. Circuit diagram of the music generator.

Table 2.

KEYS :	space	A	S	D	F	G	H	J	space	Z	X	C	V	D	N	M
CODE :	32	65	83	68	70	71	72	74	32	90	88	67	86	66	78	77
NOTE :	–	C	D	E	F	G	A	B	–	C^1	D^1	E^1	F^1	G^1	A^1	B^1

For frequencies of notes, see Table 1.

of simple transistor circuits and mechanical switches. Each transistor is driven into saturation or switched off by the mechanical switch in its base circuit. The collector potential will then be 5 V or zero respectively. This potential is applied to the relay control lines in the oscillator and in the attenuator network via D-type bistables and decoders. The circuit diagram of the music generator is given in Fig. 9.

Computer software

The flow chart (including the algorithm) of the program is given in Fig. 10, and the actual program in Fig. 11. The program is written in BASIC and stored on a floppy disk.

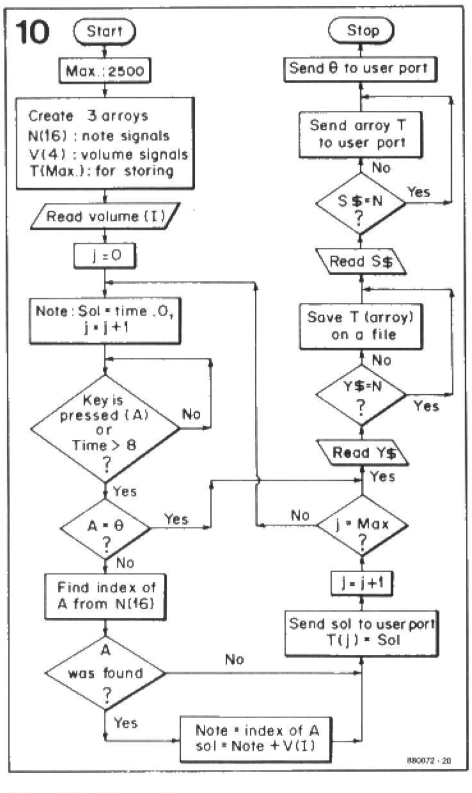

Fig. 10. Flow diagram.

As the user plays the music by pressing the relevant keys on the computer (see Table 2), the computer stores the notes in a one-dimensional array. When he finishes playing, the computer will ask whether playback is required. If the answer is YES, the computer stores the array in a file. The size of the array in which music is stored is 2,500 lines. This low number is due to the limitations of the computer memory. The array allows the playing of music for about 10 minutes.

Further possibilities

The hardware design may be interfaced to any type of PC with the appropriate A/D converters to their user ports. The software can be modified to allow the user to play music on the keyboard of other PCs. Since the BBC micro has an 8-bit user port register, it can send $2^8 = 256$ signals. It can, therefore, be used to generate 256 different notes. These notes are fundamentals, not harmonics. A volume range of 30 dB is used

11

```
*FX6,1
  10 REM        (GENERATION OF MUSIC BY USING HARDWARE AND BBC INTERFACE ) GRPT
 86 - JAN 87 ) =A
  20  REM    THIS PROGRAM IS AN                          INTERFACIN FOR
  30  REM THE COMPUTER GENERATED MUSIC
  40 WAIT=8
  50 MAX=2500
  60  DIM N(16)
  70  DIM T(MAX)
  80  DIM V(4)
  90 CLS
 100 PRINT "WELCOME TO THE MUSIC PROGRAM"
 110 PRINT "VOLUME CAN BE OF DEGREE 1,2,3 OR 4 ONLY"
 120 INPUT "VOLUME IS OF DEGREE ?"VOLUME
 130 IF VOLUME<1 OR VOLUME>4 THEN 110
 140 PRINT "PLEASE NOTE THE FOLLOWING"
 150 PRINT "YOU HAVE TWO OCTAVES"
 160 PRINT "EACH OCTAVE HAS 7 NOTES"
 170 PRINT "THE FIRST OCTAVE BEGINS AT   KEY ,Z, AND ENDS AT KEY ,M,  "
 180 PRINT "THE SECOND BEGINS AT KEY ,A, AND          ENDS AT KEY ,J,"
 190 PRINT "IF YOU WANT TO EXIT,THEN: "
 200 PRINT "PRESS THE KEY 0"
 210 V(1)=0
 220 V(2)=16
 230 V(3)=32
 240 V(4)=48
 250 FOR J=1 TO MAX
 260     T(J)=0
 270 NEXT J
 280 J=1
 290 INPUT "NOW PRESS THE RETURN KEY TO  START          PLAYING MUSIC "Y$
 300 ?&FE62=&FF
 310 *FX11,15
 320  REPEAT
 330 A=INKEY(WAIT)
 340 DATA 32,65,83,68,70,71,72,74,32,90,88,67,86,66,78,77
 350 IF A=48 THEN GOTO 470
 360 RESTORE
 370 SOT=0
 380 FOR I=1 TO 16
 390    READ N(I)
 400    IF A=N(I) THEN SOT=I-1
 410 NEXT I
 420 ?&FE60=SOT+V(VOLUME)
 430 X=?&FE60
 440 T(J)=X
 450 J=J+1
 460  UNTIL (J>MAX)
 470 ?&FE60=0
 480 PRINT "YOU CAN NOT PLAY MUSIC ANY MORE"
 490 IF J<MAX THEN T(J)=-1
 500 INPUT "DO YOU WANT TO STORE MUSIC?,              N=NO ,FOR YES PRESS RETU
RN",Y$
 510 IF Y$="N" THEN GOTO 580
 520 B = OPENOUT ("MUSIC")
 530 FOR J=1 TO MAX
 540      PRINT£B,T(J)
 550 NEXT J
 560 PRINT "YOUR MUSIC IS STORED NOW "
 570 CLOSE£ B
 580 INPUT " DO YOU WANT TO LISTEN TO STORED MUSIC? N=NO ,FOR YES PRESS RETURN"
,S$
 590 IF S$="N" THEN GOTO 700
 600 C=OPENIN ("MUSIC")
 610 J=1
 620 REPEAT
 630     INPUT£C  , X
 640  TIME =0
 650 IF TIME<= 7 THEN 650
 660     ?&FE60=X
 670 J=J+1
 680 UNTIL (J>MAX) OR (T(J)<0)
 690 CLOSE£ C
 700  *FX12,0
 710  ?&FE60=0
 720 PRINT "YOU HAVE EXIT FROM THE MUSIC PROGRAM "
 730 END
```

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Fig. 11. Listing of the BASIC control program.

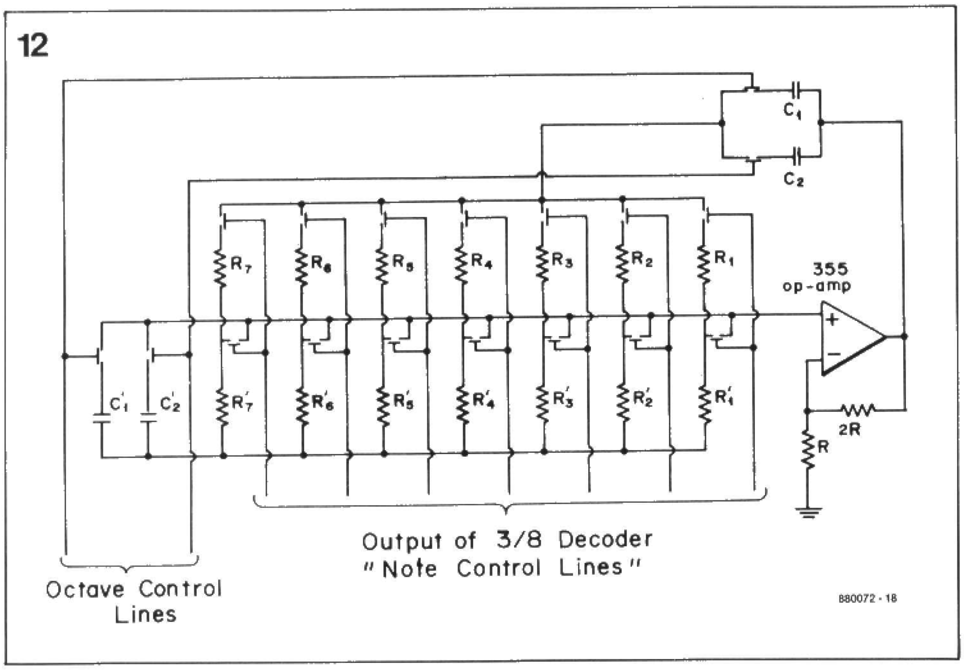

Fig. 12. General layout of the wien bridge oscillator.

at the oscillator output. The frequency of the notes may vary ±2 Hz around the exact values, but this is not noticeable by ear.
The thermistor, which protects the relays from over-heating, takes a finite time to warm up. This time and the time delays in relay operation cause the output sound from the speaker to have a small peak before becoming steady. This effect is considered to be perfectly acceptable, since in a piano the sound also peaks first before attaining a steady state somewhat below this peak value.

Finally

An instrumentation amplifier is used for the oscillator. Any frequency drift caused by temperature variations is minimized by the drift-compensation network.
The circuits are best placed in a metal box and all wiring kept as short as possible to keep any interference at bay.

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1. *Electronic Engineering* 27:330, 350 and 410, July to September 1955.
2. *Journal of the AES* 14, No. 1:21, 1966.
3. *Journal of the AES* 17, No. 258, 1969.
4. Third Int. Congress on Acoustics 1959—Elsevier Publications Co., Amsterdam.
5. *Computers and Automation*, 13 No. 8:16, 1964
6. *Microelectronic Circuits* by Adel S. SEDRA, 1982.
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8. *BBC User Guide Book*, BBC, 1982.

Acknowledgments:
The assistance of Rowida Mustafa and Akram Farhat of Kuwait University is greatly appreciated. The project was financed by an SPO23 university grant.

FUZZ UNIT FOR GUITARS

Players of the lead or rhythm guitar will appreciate the wide range of sounds produced by this low-cost fuzz unit.

The fuzz unit described here is simple to build from commonly available parts, yet gives excellent results with almost any combination of lead or rhythm guitar and guitar amplifier (valve or transistor). It has three controls that guarantee a wide range of available effects, and is relatively simple to align.

Circuit description

With reference to the circuit diagram of Fig. 1, the fuzz unit is powered via switch S_1, which is automatically closed when a jack plug is inserted in socket K_2. The output of the circuit remains short-circuited to ground, however, until a plug is inserted in K_1. This arrangement effectively prevents clicks and noises in the guitar amplifier when the effects unit is being connected. The guitar signal is applied to electronic switches IC_{3A} and IC_{3B} via coupling capacitor C_{19}. The configuration of the electronic switches is controlled by foot switch S_3 and inverter/LED driver T_1. When the foot switch is open, i.e., not actuated, R_{20} takes the control input of IC_{3B} to the positive supply level, so that the guitar signal is passed from K_1 to K_2 with a series resistance of about 90 Ω, formed by the closed electronic switch. When the foot switch is closed, T_3 conducts, LED D_9 lights, IC_{3B} is opened, and IC_{3A} and IC_{3D} are closed. The guitar signal is fed to the distortion circuit via IC_{3A} and C_1, and is returned to the amplifier via C_{16} and IC_{3D}.
The circuit around opamp IC_1, FET T_1, T_2 and rectifier D_1 is a peak limiter (clipper) whose onset-level is defined by P_1. The distortion effect is, however, not complete as yet. Coupling capacitor C_5 feeds the signal to a passive filter network. High-frequency components in the signal are boosted or attenuated when BRIGHT switch S_2 is set to position A or B, respectively. When S_2 is set to position C, the filter is largely ineffective. The filter characteristics may be defined to individual taste by redimensioning of C_{10}: the roll-off frequency of the network decreases with increasing capacitance.
Preset P_2 serves to set the optimum signal amplitude for the distortion stage set up around IC_2. The feedback network of this opamp includes R_{17} and anti-parallel diodes D_3-D_4, which introduce the required distortion. The distortion level can be set with P_3. The signal is then fed through an R-C low-pass, a diode limiter and a volume adjustment, before it is applied to the electronic switch configuration discussed above.

Construction and adjustment

Construction of the fuzz unit is a routine job: simply fit all the parts in accordance with the PCB overlay (see Fig. 3) and the parts list. Be sure to observe the polarity of the diodes and the radial electrolytic capacitors.

The completed circuit board is best fitted in a sturdy diecast enclosure, as shown in Fig. 2. The foot switch, LED, and COMPRESSION and DISTORTION controls are fitted onto the bottom plate of the enclosure. Sufficient room should be left inside to accomodate the 9 V PP3 battery, which is preferably secured with double-sided adhesive tape.

The circuit is, of course, best set up with the aid of a sinewave generator and an oscilloscope, but a rather simpler alignment procedure is set out below for constructors not in possession of these instruments. Connect the fuzz unit to the electric guitar and the power amplifier, and verify that it is being powered by the battery. Actuate the foot switch, set P_3 to the minimal resistance position, and switch off the BRIGHT filter (set S_2 to position C). Play an h note on the guitar ($f \approx 1$ kHz), and set P_1 for minimum audible distortion. Adjust P_2 and actuate the foot switch a few times until the

1

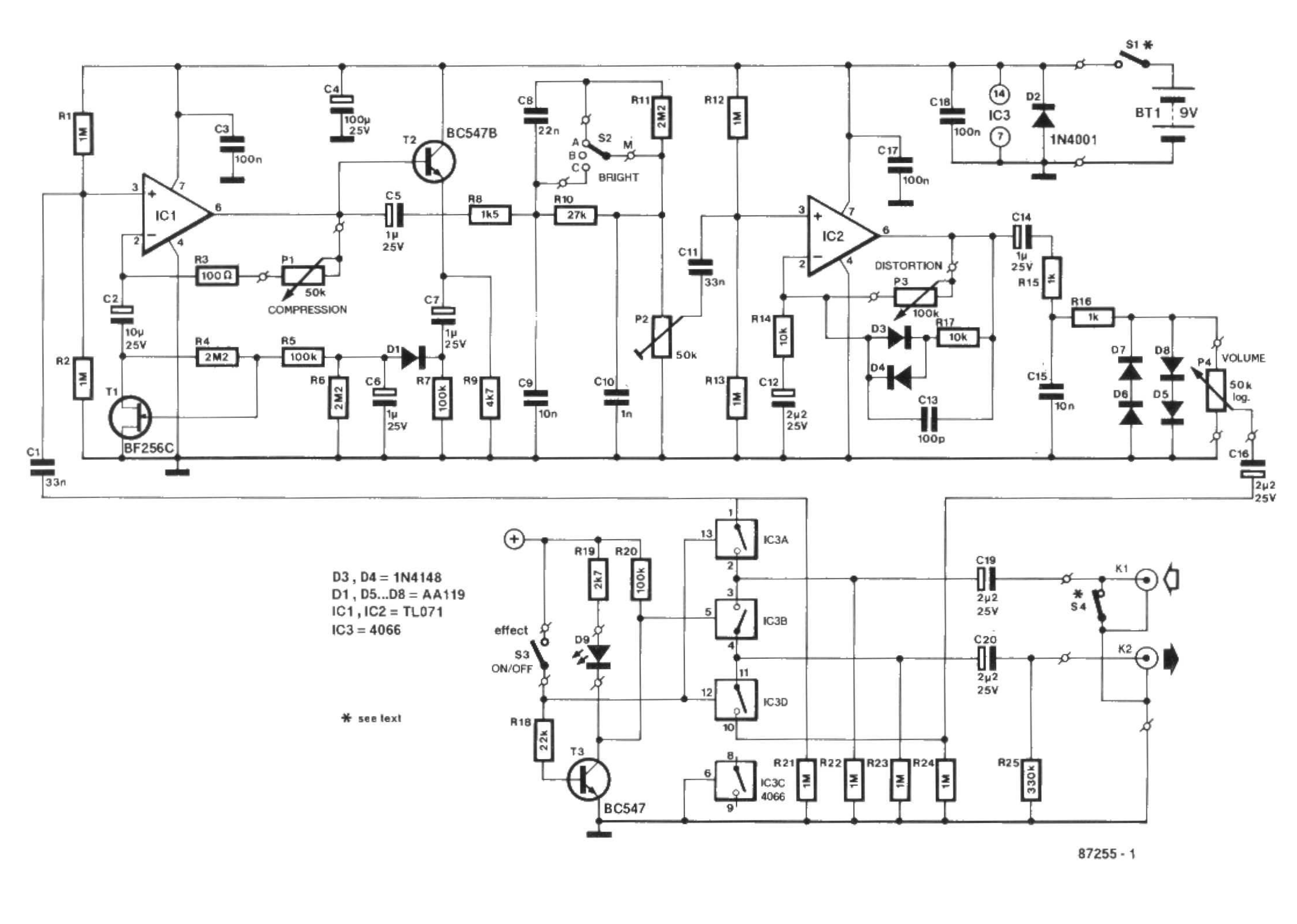


Fig. 1. Circuit diagram of the fuzz unit for electric guitars.

signal from the effects unit and the "dry" guitar signal are of equal amplitude (this also depends on the position of VOLUME control P_4).

Adjust the circuit as follows if the previously mentioned test equipment is to hand. Apply a 1 kHz sinewave of 150 mV amplitude to the input of the fuzz unit. Set the BRIGHT switch to position C (off). Connect the scope to junction S_2-P_2, and adjust P_1 for maximum amplification without running into noticeable distortion. Increase the signal amplitude to 300 mV, and reduce the distortion observed on the oscilloscope as far as possible by carefully re-adjusting P_1. Replace T_1 with a another BF256C if the distortion can not be reduced to an acceptable level: these FETs are manufactured to a relatively wide tolerance in respect of dynamic characteristics. Set the volume of the effects unit as outlined above.

The fuzz unit has a moderate current consumption, so that an alkaline PP3 battery should last for about 300 hours. This is reduced to about 40 hours, however, if D_9 is fitted. Much of the battery capacitance can be saved by using a high-efficiency LED, and increasing the value of the series resistor, R_{19}. Diode D_2 protects the fuzz unit against reverse voltage when the battery is connected with the wrong polarity. *B*

2

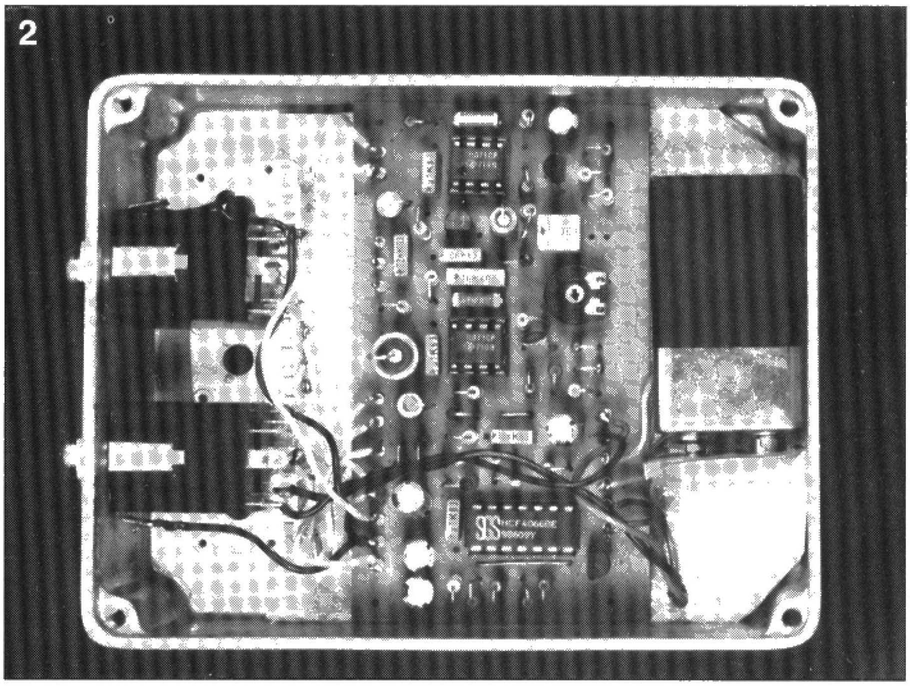


Fig. 2. Internal view of the prototype. The input and output sockets are types with a built-in switch contact.

3

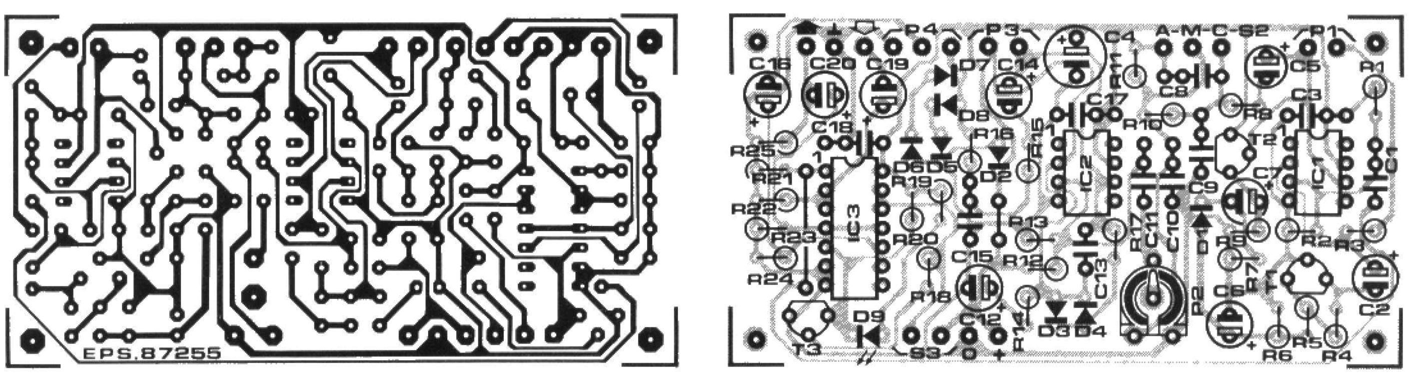


Fig. 3. The printed circuit board for building the fuzz unit.

Parts list

Resistors (±5%):

R_1;R_2;R_{12};R_{13};R_{21} . . . R_{24} incl. = 1M0
R_3 = 100R
R_4;R_6;R_{11} = 2M2
R_5;R_7;R_{20} = 100K
R_8 = 1K5
R_9 = 4K7
R_{10} = 27K
R_{14};R_{17} = 10K
R_{15};R_{16} = 1K0
R_{18} = 22K
R_{19} = 2K7
R_{25} = 330K
P_1 = 50K linear potentiometer
P_2 = 50K preset H
P_3 = 100K linear potentiometer
P_4 = 50K logarithmic potentiometer

Capacitors:

C_1;C_{11} = 33n
C_2 = 10μ; 25 V; radial
C_3;C_{17};C_{18} = 100n
C_4 = 100μ; 25 V; radial
C_5;C_6;C_7;C_{14} = 1μ0; 25 V; radial
C_8 = 22n
C_9 = 10n
C_{10} = 1n0
C_{12};C_{16};C_{19};C_{20} = 2μ2; 25 V; radial
C_{13} = 100p
C_{15} = 10n

Semiconductors:

D_1;D_5 . . . D_8 incl. = AA119
D_2 = 1N4001
D_3;D_4 = 1N4148
D_9 = LED (red)
T_1 = BF256C
T_2 = BC547B
T_3 = BC547
IC_1;IC_2 = TL071
IC_3 = 4066

Miscellaneous:

K_1;K_2 = headphone socket for 6.3 mm plug (with built-in switch).
S_1 = SPST switch in socket (normally open).
S_2 = 3-way, single-pole, rotary switch.
S_3 = foot switch.
S_4 = SPST switch in socket (normally closed).
PCB Type 87255 (see Readers Services page).

MIDI CODE GENERATOR

SEE OCTOBER 1988
P. 65 FOR MODS / CORRECTIONS

In line with this month's theme, electrophonics, we present a handy, versatile and inexpensive to build tool that helps tracing down and resolving incompatibility problems encountered in setting up relatively complex configurations of MIDI instruments.

by R. Degen

The acronym MIDI (MUSICAL INSTRUMENT DIGITAL INTERFACE) is nowadays known to virtually every user of electronic instruments and associated equipment. Since its introduction in 1983, the MIDI standard has gained wide acceptance, and has proved relatively simple to implement thanks to the use of a serial transmission standard for data exchange between compatible instruments in a network. Experienced users of MIDI equipment are, however, also aware of the system's limitations. One of the best known problems associated with the MIDI standard is that it becomes more difficult to manage with increasing complexity of the equipment configuration: the more instruments, the more instrument-specific codes, and the greater the risk of addressing equipment with incorrect or non-recognized codes.

Troubleshooting

Any electronic musical instrument fitted with a serial asynchronous interface to the MIDI standard (31.25 Kbit/s; $\pm 1\%$) has a receiver and/or transmitter circuit. Transmission of an 8-bit dataword commences with one start bit, and is terminated with one stop bit. The 10-bit pulse train has a duration of 320 μs. The interface is essentially a 15 mA current loop built around an opto-coupler. Each output preferably drives only one input, and received signals are, therefore, reshaped and fed to a MIDI THRU output.
The MIDI communications protocol distinguishes between status bytes (>127), followed by one or more databytes (<128), real time messages, and exclusive messages.
The code generator proposed here is a MIDI compatible accessory device that enables sending any 8-bit hexadecimal code ($0 \ldots 255_{10}$ or $00 \ldots FF_{HEX}$) to an instrument fitted with a MIDI input. But why bother to generate single commands at typing speed when the MIDI interface is geared to high-speed communication? The answer has already been hinted at in the above introduction. The need for developing the MIDI code generator arose from difficulties encountered in working with incompatible MIDI instruments of different type and make. It often happens that a relatively complex set-up of instruments and other devices connected via MIDI links simply does not work as required. Finding the cause of the malfunction is not easy, especially in relatively complex instrument set-ups. The speed at which data is carried between instruments is so high as to make code analysis without relatively complex equipment virtually impossible.
A simple test device as described here allows sending MIDI datawords sequentially to an individual instrument by pressing 2 keys on a keypad. In this way, even the most complex MIDI control strings can be generated to enable checking the instrument's response. This way of testing may be compared to using an AF test generator plus oscilloscope to trace down a fault in an amplifier.
Most MIDI instruments are supplied with a manual that gives more or less detailed tables listing the MIDI codes that are recognized or transmitted by the instrument. These 2-character codes (MIDI datawords) can be supplied by the circuit described here: the code is generated and transmitted by sequentially pressing the 2 appropriate keys on a hexadecimal keyboard. LEDs indicate the transmission of the first and second character in the MIDI dataword.
The code generator is essentially composed of the following functional blocks: keyboard encoder, parallel-to-serial converter, central clock, and a driver for the status indication LEDs. The unit operates autonomously from a regulated power supply.

Circuit description

Essentially, the circuit fetches two hexadecimal characters from the 16-key keypad, combines them into a single dataword, and transmits this in the previously discussed MIDI format. There is no parity bit, and the serial dataline is logic "1" in the non-activated state.

Figure 1 shows the circuit diagram of the MIDI code generator. The circuit is composed entirely of conventional HCMOS integrated circuits, and is, therefore, inexpensive to build.

Oscillator N_1-N_2 feeds the central clock signal via N_3 and N_7 to binary counter IC_6, whose 4-bit output QA...QD supplies the binary equivalents of numbers 0...15 incl. to keyboard encoder IC_1, latch IC_2 and shift register IC_5. The clock signal for counter IC_6 is inhibited in N_7 by the "keyboard activity" signal obtained via Schmitt-trigger N_{10} and inverter N_6.

When power is applied to the circuit, bistable FF_1 is reset by network R_3-C_2. Output Q of FF_1 is logic low, so that N_5 provides a logic high level to LED driver T_1. D_1 lights to indicate that the code generator awaits the first, most significant, hexadecimal character (MS nibble).

Assuming that none of the keys is pressed, N_7 passes the clock pulses to counter IC_6. The keyboard encoder, IC_1, is a 4-to-16 demultiplexer that translates the 4-bit binary code at its inputs A...D into a low pulse at the relevant output. Each demultiplexer output is connected to a key, S_1...S_{16}. If, for example, key S_{11} is pressed (nibble A_H), the clock signal is inhibited the instant IC_1 activates output 10. This means that the binary equivalent of "10" is latched in IC_2, becauses the rising edge of the pulse supplied by N_{10} causes FF_1 to toggle and clock IC_2 via output Q. Latch IC_2 supplies the 4-bit binary code corresponding to the MS nibble of the MIDI dataword to the parallel load inputs of shift registers IC_4 (inputs G and H) and IC_5 (inputs A and B). Inverter N_5 supplies a logic low level to T_1, D_1 is turned off, and D_2 lights to prompt the user to enter the LS nibble on the keypad. Releasing the key restores the clock signal for IC_6, and restarts the keyboard scan activity. When the second character is typed in, the corresponding binary code of the LS nibble is present on inputs C...F of IC_5. Output Q of FF_1 goes logic high, and N_9 activates the SHIFT / $\overline{\text{LOAD}}$ inputs of the shift registers, IC_4 and IC_5. These load the 8-bit datawords at their inputs A...H, and are switched to the SHIFT mode when the output of N_9 goes high, which happens when the key is released. The MIDI dataword is converted to serial format, and shifted out via inverter N_4. Simultaneously, FF_1 receives a new clock pulse, and output Q reverts to logic low. Counter IC_6 is clocked again, and LED D_1 indicates that a new MS nibble may be entered via the keyboard.

The start and stop bit required in the MIDI dataword are obtained by connecting output Q_H of IC_4 to input SER of IC_5. It is seen that SER on IC_4 is made permanently logic high, together with inputs A...F incl. (these are the 6 nonused bits of the 16-bit shift register formed by IC_4-IC_5). The shifting out of bits applied to the parallel inputs is followed by that of the bit applied to SER, so that IC_4 supplies a series of logic high pulses after the 4 databits. After a few clock pulses, these bits are also present on the serial output of IC_5. Together with input bit H of IC_5 (a permanent logic "1"), these form a series of stop bits. The start bit is loaded into IC_1 as the logic low level permanently applied to input G. The complete MIDI command is, therefore, defined by the parallel data received via inputs G, F...A (IC_5), G, H, F...A and SER (IC_4) in that order.

Finally, preset P_1 enables accurately setting the serial bit rate on the MIDI OUT line to 31.250 Kbit/s.

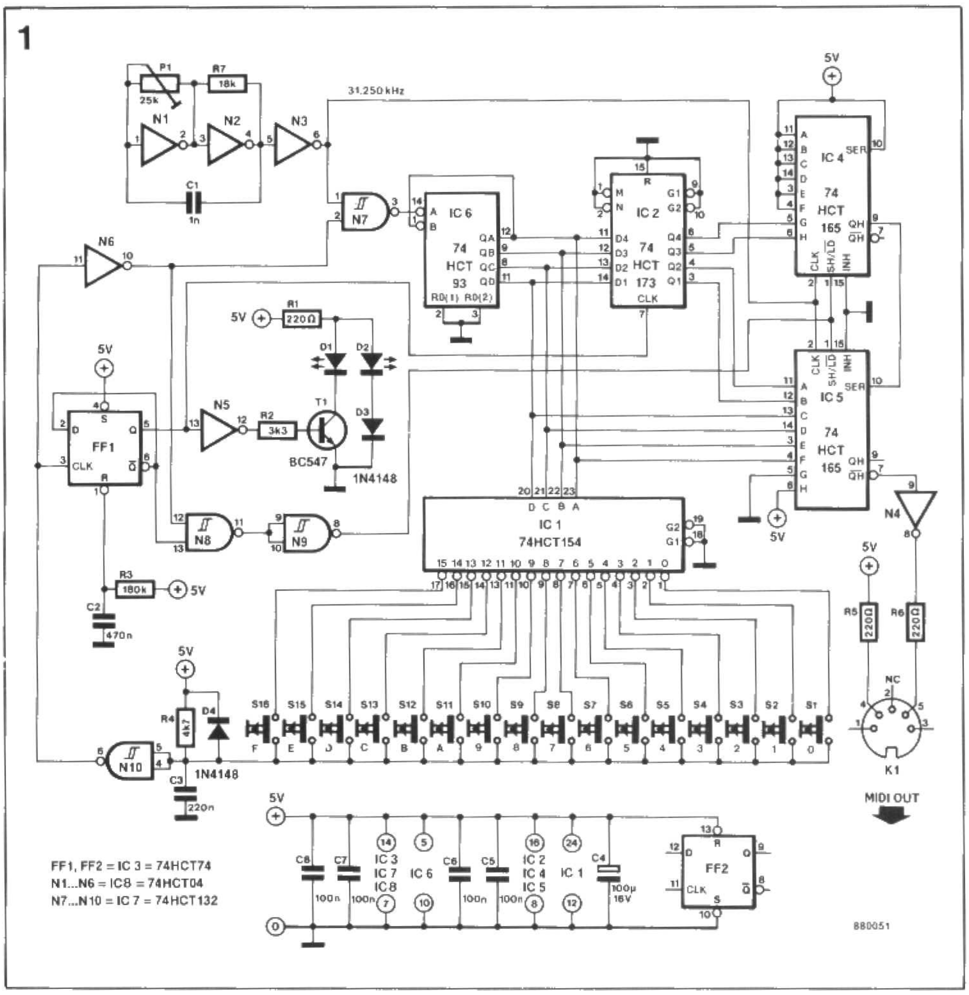


Fig. 1. Circuit diagram of the MIDI code generator.

Construction and use in practice

A prototype of the MIDI code generator was constructed on a piece of veroboard as shown in the accompanying photograph. The wiring was made in thin enamelled copper wire, fitted at the rear side of the board. The DIN socket and the 16 Digitast keys are conveniently mounted direct onto the component side of the board. The circuit is best fitted in a sturdy enclosure if portable operation

Parts list

Resistors (±5%):
R_1;R_5;R_6 = 220R
R_2 = 3K3
R_3 = 180K
R_4 = 4K7
R_7 = 18K
P_1 = 25K or 22K preset

Capacitors:
C_1 = 1n0
C_2 = 470n
C_3 = 220n
C_4 = 100μ; 16 V
C_5...C_8 incl. = 100n

Semiconductors:
D_1;D_2 = LED
D_3 = 1N4148
IC_1 = 74HCT154
IC_2 = 74HCT173
IC_3 = 74HCT74
IC_4;IC_5 = 74HCT165
IC_6 = 74HCT93
IC_7 = 74HCT132
IC_8 = 74HCT04
T_1 = BC547

Miscellaneous:
K_1 = 5-way DIN socket for PCB mounting.
S_1...S_{16} incl. = Digitast key (ITT Schadow).
Veroboard as required.
Note: it regretted that a ready-made PCB for this project is not available.

MIDI - frequently used codes

Note: all codes are given in hexadecimal notation

Channel Voice Messages

STATUS	DATA	DATA	
80...8F	00...7F	00...7F	NOTE OFF (+ channel number) + note number + VELOCITY
90...9F	00...7F	00...7F	NOTE ON (+ channel number) + note number + VELOCITY
A0...AF	00...7F	00...7F	POLYPHONIC KEY PRESSURE/AFTER TOUCH (+ channel number) + note number + PRESSURE VALUE
B0...BF	00...79	00...7F	CONTROL CHANGE (+ channel number) + CONTROL + VALUE
C0...CF	00...7F		PROGRAM CHANGE (+ channel number) + PROGRAM
D0...DF	00...7F		CHANNEL PRESSURE/AFTER TOUCH (+ channel number) + VALUE
E0...EF	00...7F	00...7F	PITCH WHEEL CHANGE (+ channel number) + CHANGE LSB + CHANGE MSB

In each message, the four least significant bits designate the channel number (1...16 incl.; 0=channel 1; F=channel 16). Example: 97=NOTE ON for channel 8. The status words given below are always followed by one or two databytes (<80) as required.

Note numbers:

6C (108): DOH high (88 keys)
60 (96) : DOH high (61 or 73 keys)
45 (69) : LAH 440 Hz
3C (60) : DOH from keyboard centre
24 (36) : DOH low (61 keys)
18 (24) : DOH low (73 keys)
15 (21) : LAH low (88 keys)

VELOCITY:

0 : NOTE OFF (do not use 0 as default value)
1 : ppp (pianissimo)
40: mp-mf (mezzo-forte); default value
7F: fff (fortissimo)

System Messages

F0	SYSTEM EXCLUSIVE (consult documentation supplied with equipment)
F1...F7	SYSTEM COMMON
F1	not defined
F2	POSITION POINTER (+ 2 databytes)
F3	SONG SELECT (+ 1 databyte)
F4...F5	not defined
F6	TUNE REQUEST
F7	EOX (marks the end of message SYSTEM EXCLUSIVE)
F8...FF	REAL TIME
F8	TIMING CLOCK
F9	not defined
FA	START
FB	CONTINUE
FC	STOP
FD	not defined
FE	ACTIVE SENSING
FF	SYSTEM RESET

Channel Mode Messages

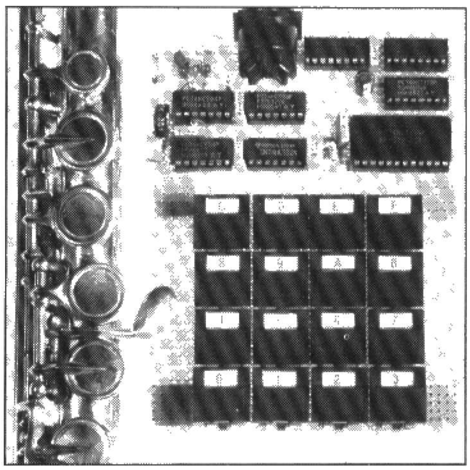
B0...BF	7A...7F	0...7F	CHANNEL MODE (+ channel number) + MODE + MODE
B0...BF	7A	0	CHANNEL MODE (+ channel number) + LOCAL CONTROL OFF
B0...BF	7A	7F	CHANNEL MODE (+ channel number) + LOCAL CONTROL ON
B0...BF	7B	0	CHANNEL MODE (+ channel number) + ALL NOTES OFF
B0...BF	7C	0	CHANNEL MODE (+ channel number) + OMNI MODE OFF (ALL NOTES OFF)
B0...BF	7D	0	CHANNEL MODE (+ channel number) + OMNI MODE ON (ALL NOTES OFF)
B0...BF	7E	0...F	CHANNEL MODE (+ channel number) + MONO MODE ON (POLY MODE OFF) (ALL NOTES OFF) + NUMBER OF CHANNELS (0=all receiver channels)
B0...BF	7F	0	CHANNEL MODE (+ channel number) + POLY MODE ON (MONO MODE OFF) (ALL NOTES OFF)

is envisaged. The supply voltage for the circuit is obtained from a NiCd battery or a suitable mains adapter.
Set P_1 to the centre of its travel, and the code generator is ready for testing in a MIDI environment. The MIDI output on the generator corresponds to a standard MIDI OUT connection, and can be used for feeding otherwise unavailable codes to certain equipment. Similarly, the code generator can be used in conjunction with an expander for realizing MIDI functions not supported by a standard MIDI keyboard.

Use a standard MIDI cable for connecting the code generator to an instrument that is known to respond to, say, the NOTE ON/NOTE OFF command. Program this instrument to listen to MIDI channel 1, and send the following code sequence:
90 3C 40.
The function of these three bytes is as follows (also consult the accompanying overview of frequently used MIDI codes):
90 selects the NOTE ON mode on channel 1;
3C is the note number (''doh'' from the centre of the keyboard);
40 is a commonly used velocity code.
Carefully adjust the oscillator clock frequency if this does not work. If necessary, use a frequency meter connected to the output of N_3 to set the clock oscillator to 31,250 Hz.
End the played note by typing:
80 3C 40. *R*

Some useful articles on MIDI:

Fantasia on a MIDI theme. *Elektor Electronics* November 1985, p. 52 ff.
MIDI expander from Böhm. *Elektor Electronics* March 1986, p. 21 ff.
MIDI split control. *Elektor Electronics* March 1987, p. 31 ff.
MIDI signal redistribution unit. *Elektor Electronics* May 1987, p. 20 ff.



TEST & MEASURING EQUIPMENT

Part 1: dual-trace oscilloscopes (E)

The final article in Julian Nolan's review of dual trace oscilloscopes deals with the Hung Chang OS-635.

The Korean company of Hung Chang is, perhaps, better known for its range of DMMs, frequency sources, and counters, some of which are sold under a variety of retail trade names.

The Hung Chang OS-635 is a 35 MHz delayed sweep oscilloscope with a 6 kV CRT retailing at £399 (excl. VAT), which is only about £80 more than one would expect to pay for a 'basic' 20 MHz model.

The delayed sweep is of the 'coarse' variety; the instrument is also fitted with trigger hold-off and single sweep modes.

The OS-635 is fitted with a standard IEC mains socket. The line voltage is externally adjustable to 100, 120, 220, or 240 VAC.

The instrument is not fitted with a swivel stand, but the single position stand provided instead allows easy stacking of the unit.

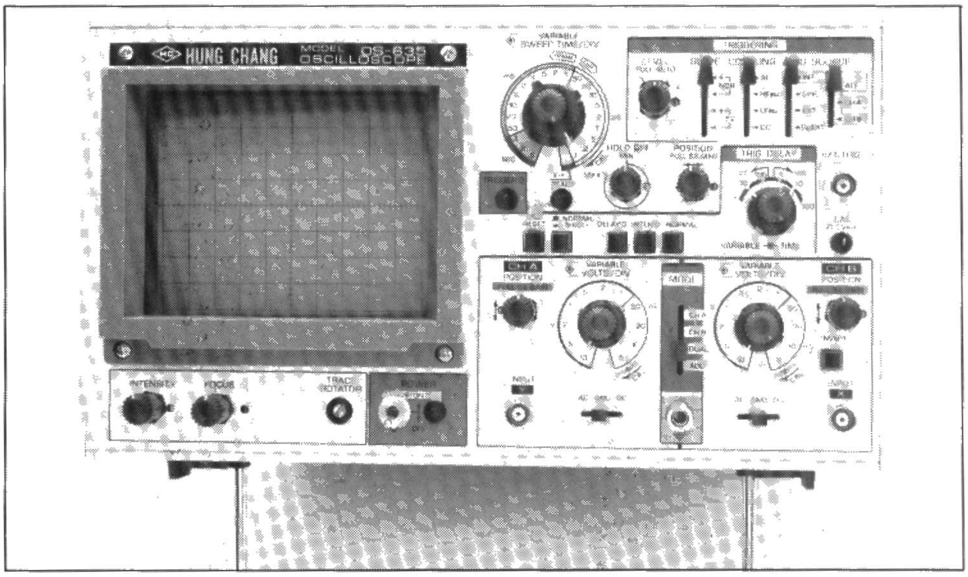
The OS-635 is of average depth and width: 352 mm and 294 mm respectively, but its height of 162 mm is perhaps rather more than might be expected.

Two high-quality probes (1.4 ns rise time when in 10:1 attenuation mode) are supplied as are accessories for use with them, including a BNC adaptor and spring-loaded clip.

Front panel. The front panel is probably one of the OS-635's most distinguishing features, with colour-coded sections such as triggering and Y-amplifier functions. Although the colour coding adds to the ease of operation, the panel is not, as common, anodised, but the markings have been printed on. This, together with the exposed potentiometer bushes of some controls, gives the instrument a rather rough and ready appearance. However, this certainly does not mean that it is of low quality.

Y-amplifiers. The attenuation coefficient of both Y-amplifiers is variable over a range of 10 V/div to 5 mV/div. In addition to this, a ×5 magnification facility is also available, enabling maximum sensitivities of 1 mV/div to be achieved.

Undoubtedly, one of the main features of the OS-635 is its 35 MHz bandwidth.



This is maintained down to 5 mV (−3 dB). The 1 mV/div sensitivity brings with it the restriction of a 10 MHz bandwidth (rise time 35 ns).

Both Y-amplifiers have a continuously variable attenuation control, which increases the maximum attenuation coefficient to 30 V/div. Only one channel can be inverted.

The performance of the Y-amplifiers is reasonable in terms of frequency response and bandwidth, given their relatively high frequency range. But, despite these mediocre characteristics, they are still undoubtedly better than the average 20 MHz Y-amplifier at this price level.

Despite being specified at 3%, overshoot is particularly evident on some ranges, although it remains within the quoted limit.

The dynamic range is somewhat limited at about 4½ divisions at 35 MHz, but should, none the less, be acceptable for most purposes.

A minor point is that the ×5 magnifier has the effect of magnifying the trace offset, which is set by the Y position control, with the result that some repositioning of the trace is required when the ×5 magnifier is actuated.

Since the ×5 switches are incorporated in the Y position controls, it happens that when these controls are accidentally turned when they are pulled out to actuate the ×5 magnifier, the trace shifts. If this has already been centred, an unnecessary adjustment is required to recentre it.

Chopped (200 kHz) or alternate sweep is selected automatically by the time base speed setting.

Triggering. Triggering on the OS-635 is comprehensive, including LF and HF filtering, alternate channel sourcing and TV synchronization. In addition to this, unusually for a scope in this price range, an external ÷10 facility is also provided.

The auto/normal and triggering threshold controls are combined into one in a similar manner to the ×5 attenuation coefficient magnifier. Here, the problems brought about by this are not so acute, but still noticeable; the auto position is selected with the level control fully out. All other triggering controls (of the slider type) are, however, relatively easy to operate.

TV triggering is particularly notable, being selectable from positive or negative synchronization and, with the inclusion of automatic line and frame switching, incorporated into the timebase coefficient selector. Triggering sensitivity is also good: typically 0.2 div to 10 MHz, increasing to 1 div at 35 MHz and 3 div

Table 17.

ELECTRICAL CHARACTERISTICS
line voltage: – 100, 120, 220, 240 VAC ± 10%, externally adjustable. Power consumption: 30 Watts
Line frequency: 50-60 Hz

MECHANICAL CONSTRUCTION
Dimensions: – W 294 mm, H 162 mm, D 352 mm
Housing steel sheet
Weight: approx. 7.5 kg

Y AMPLIFIER ETC.
Operating modes: –
CH1 alone, CH2 alone.
Inversion capability on CH2 only.
Any combination of CH1, CH2 (alternate or chopped (250 kHz))
CH1 + CH2
Frequency response 0. . .35 MHz (–3 dB).
Risetime < 10 nsec, (35 nsec × 5 Mag.)
Deflection factor 10 steps:
5 mV/div. . .5 V/div ± 3%.
×5 magnifier extends range to 1 mV/div, MHz bandwidth.
Input coupling: AC, DC or Gnd.
Input impedance: 1 MΩ/25 pF; max input voltage 300 (DC + peak AC)

X-Y MODE
CH1 X-axis and CH2 Y-axis. Less than 3° phase shift at 50 kHz
Bandwidth DC to 1 MHz (–3 dB).

SWEEP
Operating modes – normal: timebase A displayed (no delay); intensified: timebase A intensified by trig delay over magnification area; delayed: A sweep starts after delay time.
A sweep time 100 ns/div to 0.5 s/div ±3% in 21 ranges; 1-2-5 sequence; vernier control slows sweep down by up tp 2.5:1.
Delay time – 10 ms to 1 μs in 5 steps, 1:1 sequence; variable control for fine adjustment.
Sweep magnification – ×5 ±10% total error.
Hold off – variable up to 10:1.
Delay modes – continuous delay.
Delay jitter – 1/5000.
Single sweep facility.

TRIGGERING
Trigger modes – auto and normal.
Trigger coupling – AC; DC; HF reject; LF reject; TV frame and line (auto).
Trigger sources – Ch; Ch2; alternate; line; ext.; ext/10.
Triggering sensitivity – internal: 1 div at 35 MHz; external: 0.2 V_{pp} at 35 MHz.

MISCELLANEOUS
CRT – measuring area 80×100 mm; accelerating voltage 6 kV; metal backed; PDA.
Compensation signal for divider probe – amplitude approx. 0.5 V_{pp} ±3%; frequency 1 kHz.
Z modulation sensitivity – 3 V (complete blanking).
Warranty – 1 year.

at 60 MHz, which is the maximum reliable trigger frequency. External trigger sensitivity is also good at 100 mV to 10 MHz and 0.2 V to 35 MHz. This can, however, be increased by means of the ÷10 control to eliminate false triggering, caused, for example, by noise. An alternate channel, or composite mode, is also incorporated for observation of two unrelated (in terms of frequency) signal sources. Triggering symmetry (rising or falling slope) proved to be out by approximately 1 division over a total vertical deflection of 8 divisions. The HF and LF facilities provided are effective in obtaining a stable trace even in cases of waveforms with a very high modulation content, and are a further useful addition to the OS-635's trigger functions. Both trigger and 'ready' LEDs are also incorporated, lighting when the scope is stably triggered or reset respectively. Trigger holdoff is also a feature of the OS-635, which makes the triggering facilities provided by this scope amongst the best in its class.

Timebase. The OS-635 is equipped with a single timebase and an uncalibrated vernier delay time control. This has the consequence that in the vast majority of situations only uncalibrated delayed sweep measurements can be made of waveforms which exceed the maximum horizontal deflection limit of 10 divisions. In most cases this limitation does not affect the measurement of waveform rise times.
The main timebase itself ranges from a respectable 0.5 s/div to 100 ns/div, although, obviously to limit the cost of the deflection circuitry, only a ×5 horizontal magnification system has been incorporated, increasing the maximum deflection speed to 20 ns/div. The trigger delay time coefficient can be selected from one of 5 (the front panel is marked for 6) covering the range from 1 sec to 100 msec in a 1:1 sequence. This departure from the standard 1-2-5 sequence is false economy since, although it reduces the number of switch positions to 5 instead of 15, highly accurate adjustment of the vernier control is required at higher magnification levels. It also has the effect of reducing the ease of use of the delayed sweep facility significantly in my opinion, largely due to the accurate vernier adjustments which have to be made. Rise time measurements would have been greatly helped by the provision of a triggered delay facility in addition to the normal continuous mode, as well as a delay line. Looking at the situation in perspective however these facilities can hardly be expected for £399, but effective operation of the delayed sweep facility without them may in many applications prove extremely difficult. The delayed sweep display modes of normal, intensified or delayed should be adequate for most purposes.
Timebase accuracy is inside the specified ±3% (and the rather high ±10% when using the ×5 magnifier). Linearity is also within the quoted ±3% over most of the range, although it is noticeable at the start of the trace over the first 1½ small divisions on the maximum timebase speed that the deflection characteristics were, to say the least, non-linear.

CRT. The 6 kV tube enables both good intensity and brightness to be maintained over the whole range of sweep speeds. The CRT itself is of the metal backed PDA variety and gives a good performance, especially in terms of focusing, which is certainly of a high standard. The tube is slightly curved across its face, however, and while this is not to a great degree, and should not affect measurements, it is still worth noting. Tube geometry is reasonable, with some barrelling and pincushioning present. The tube's good performance is hindered by the lack of an automatic focusing circuit, with the consequence that any major alterations in tube brightness can cause considerable defocusing of the trace, making some form of focus adjustment essential for

Table 18.

CATEGORY	Unsatis-factory	Satis-factory	Good	Very Good	Excellent
TRIGGER FACILITIES					×
TRIGGER PERFORMANCE				×	
DEL'D SWEEP FACILITIES			×		
DEL'D SWEEP PERFORMANCE			×		
CRT BRIGHTNESS					×
CRT FOCUSING				×	
Y AMP ATTENUATION RANGE				×	
INTERNAL CONSTRUCTION			×		
EXTERNAL CONSTRUCTION		×			
OVERALL SPECIFICATION					×
OVERALL PERFORMANCE			×		
EASE OF USE			×		
MANUAL				×	

accurate measurements.

Construction. Construction of the OS-635 is poor. While mostly not of low quality, the OS-635 is in places poorly finished, with a number of sharp edges evident on the enclosure both internally and externally. Internally, masking tape and small pieces of dowelling are used to separate some of the wire interconnections, which, while perhaps not impairing the reliability of the instrument, are really unacceptable in a modern instrument.
External construction is based on a steel chassis, with two sheet steel panels enclosing the top, sides and underneath of the scope. These appear to have had little done to them in terms of machining since being originally pressed and folded since they still contain one or two sharp edges. The front panel surround is constructed from four separate pieces of aluminium with the consequence that they are joinded at each corner.
Internal construction is of a higher standard, with the high voltage and EHT supplies enclosed, and the Y-amplifiers partially screened. The scope is based around four PCBs, connections from which are all made by connectors for easier servicing and while this leads to a large number of interconnections, it should not affect reliability. As well as being used to separate some of the interconnections, masking tape is also used around the CRT.
Overall construction both internally and externally appeared to be average in its class, and whether this will effect the reliability remains to be seen. The quality of components used is generally good and this may be worth taking into account.

Manual. The 30 page manual includes a full circuit and PCB layout diagrams. A full circuit description and initial set up information is also given, along with calibration and preventative maintenance sections.

Conclusion. Looking at the specification alone, the OS-635 appears to represent a extremely good price/performance ratio, with a 35 MHz (−3 dB) bandwidth, 6 kV PDA tube and delayed sweep facility. In reality, some of these facilities are limited in their performance, which is especially true of the delayed sweep facility, which in some situations offers little more than can be achieved with a scope that possesses a good trigger performance. Having said this, both the triggering performance and facilities offered by the OS-635 are good for a scope in its class and should not be ignored. An automatic focusing circuit is not fitted, which is unfortunate since the 6 kV PDA is capable of producing a trace of both excellent intensity and sharpness, but to maintain this without the provision of an automatic focusing circuit requires an adjustment in the focusing potential for a significant change in trace intensity. Both the internal and external construction have the appearance of a preproduction prototype rather than a production model, but despite this there is not apparent reason why the OS-635 should not be reasonably rugged in a variety of environments. To sum up, for its specification the Hung Chang represents a very good price/performance ratio, its particular strengths lying in its 6 kV CRT and 35 MHz bandwidth. The OS-635 may well be worth considering for a large number of applications where a bandwidth of 35 MHz and high brightness tube are required on a limited budget, or as a cost effective alternative to a 20 MHz scope.

The Hung Chang OS-635 was supplied by Black Star Ltd. • 4 Harding Way • St. Ives • HUNTINGDON PE17 4WR • Telephone (0480) 62440

Other oscilloscopes available in the Hung Chang range.
OS-615S — dual trace 15 MHz portable; rechargeable battery operated; weight 4.5 kg; sensitivity 2 mV; maximum deflection speed 100 ns/div; 1.5 kV CRT; up to 2 hours operation from fully charged batteries; £399 excl. VAT.

OS-620 — dual trace 20 MHz; sensitivity 5 mV; maximum deflection speed 40 ns/div; 2 kV CRT; component tester; power consumption 19 W; £295 excl. VAT.

OS-650 — dual trace 50 MHz; sensitivity 1 mV; maximum deflection speed 40 ns/div; 17 kV CRT; delayed sweep 100 ms to 1 μs; £579 excl. VAT.

INSTRUMENT NEWS

Programmable synthesizer/function generator

Crystal-controlled long-term stability and reproducibility are two of the major benefits offered by the Philips PM5191 programmable synthesizer/function generator now available from **Electronic Brokers • Dorcan House • Meadfield Road • LANGLEY SL3 8AL • Telephone (0753) 44878.**

IEEE488 (GPIB) Bus Analyser from Thurlby

The Kenwood LA-1910 GPIB Bus Analyser is available from • Thurlby Electronics Ltd • New Road • St. Ives • HUNTINGDON PE17 4BG • Telephone (0480) 63570.

Data Line Monitor

The Comtest DLM 100 Data Line Monitor, a time and trouble saving tool for monitoring RS232 communications, is available from **M-Trade (UK) Ltd • P.O. Box 35 • LONDON SW1W 8TX • Telephone 01-730 0681.**

Sine-wave inverters

Abulon have launched a new range of portable, low-cost, high-quality static sine-wave inverters for operation from mains or 12/24 V DC supplies. Details from **Abulon Electronic Systems • Unit 233 • Stratford Workshops • Burford Road • LONDON E15 2SP • Telephone 01-47– 9644.**

AF Power Meter from Crotech

A new AF power meter, Type 2018, can measure outputs of up to 150 W into 4, 8, or 16 ohms loads and is available from **Crotech Instruments Ltd • Stephenson Road • St. Ives • HUNTINGDON PE17 4WJ • Telephone (0480) 301818.**

New storage unit for Schlumberger Data Logger

In response to market demand, Schlumberger Instruments has upgraded its industry-standard Solartron Orion series data loggers, introduced a new data storage medium to improve logging speed and transportability of results. **Schlumberger-Solartron • Victoria Road • FARNBOROUGH GU14 7PW • Telephone (0252) 544433.**

Dual-channel signal analyser from Bruel & Kjaer

By bringing new flexibility and ease of use to fast Fourier analysis, the 2034 dual-channel signal analyser makes this fast and precise technique useful in many more sound and vibration measurement applications.

Bruel & Kjaer (UK) Ltd • Harrow Weald Lodge • 92 Uxbridge Road • HARROW HA3 6BZ • Telephone 01-954 2366.

Single function instruments from ITT

New from ITT Instruments is the MX series of single function instruments which are suitable for a wide range of professional and laboratory applications. The range comprises the MX029 voltmeter, the M039 ammeter, and the MX038 centre zero ammeter. **ITT Instruments • 346 Edinburgh Avenue • SLOUGH SL1 4TU • Telephone (0753) 824131.**

ACTIVE LOUDSPEAKER SYSTEM

The loudspeaker system published last month is ideal for being combined with the active phase linear network published last year and Sanyo's new series of output amplifier modules.

The closed box design for the *Uniphase Loudspeaker System* [1] is ideal for an active three-way system based on the *Active Phase-linear Cross-over Network* [2] and Sanyo's Type STK-4036XI 50-watt output amplifier module. The positioning of the drive units in this box is such that the phase differences at the cross-over points of the three units is virtually zero. This further accentuates the excellent phase behaviour of the phase-linear network.

Many output amplifier modules have not been well received by some audio designers in the past. Much depended, of course, on the type and manufacturer of these devices. However, the manufacturers have not been idle, and nowadays there are a number of excellent modules on the market. For a number of reasons, the choice for the present design has fallen on Sanyo's STK-4036XI.

The design also incorporates a sophisticated protection circuit that was originally published in 1985[3].

The STK-4036XI

Most output amplifier modules are hybrid circuits and the STK-4036XI is no exception. In essence, a hybrid module is nothing but a small board onto which a number of chips and passive components have been mounted, after which the whole has been encapsulated.

The new Sanyo series of output amplifier modules is identified by the letters XI following the type number. The series consists of 7 models, STK-4036XI to STK-4048XI, which provide outputs from 50 W to 150 W, all into 8 ohms. A survey of the entire series is given in Table 1. A noteworthy characteristic in the table is the very low harmonic distortion of the modules.

Compared with the previous models, the XI series has been extended internally as shown in Fig. 1, which illustrates the types 4036XI to 4042XI.

The input stage consists of a differential amplifier, Tr_3 and Tr_4, which is loaded by current mirror Tr_1-Tr_2. The signal at the collector of Tr_3 is applied to cascode amplifier Tr_6-Tr_7. The DC setting of the input and cascode stages is effected by two constant-current sources, Tr_5 and Tr_9.

The output stages consist of transistors Tr_{10}-Tr_{13}. In the XI series, in contrast to the previous models, complementary transistor pairs are used, which is a good step forward.

Darlington Tr_8 provides the quiescent current setting. Not, perhaps, an original idea, but it is reliable and generally gives good results.

The additional material required is shown in Fig. 2. It consists mainly of the power supply (2b) and a number of high wattage resistors, electrolytic capacitors and frequency compensation components. The latter are omitted from the module deliberately by the manufacturer to give designers the freedom to determine the bandwidth of the amplifier.

When reading through the description of Fig. 2, it is advisable also to glance at Fig. 1 from time to time to see what is connected inside the module to the various pins.

The symmetrical supply for the module is applied to pins 12 and 14. The preamplifier stages are powered by a voltage derived from the main supply via pins 5 and 15. Networks R_7-C_9 and R_8-C_{11} reduce the effect to the preamplifier stages of voltage variations in the main supply.

A feedback circuit, including active DC correction provided by integrator IC_2, is inserted between the output (pin 13) and the inverting input (pin 2). The amplification of the module is determined by the ratio R_3:R_4. With the values of these components as stated, the gain amounts to just under 27 dB.

The output signal from the module is also applied to low-pass filter R_{14}-C_{15} and then compared in IC_2 with the Q point of the amplifier. Any deviations are fed to the inverting input of the module (pin 2) via R_{13}. This arrangement obviates the need for an electrolytic capacitor in the feedback loop, which is distinctly noticeable in the quality of the reproduced sound[4].

Capacitors in the input circuit are MKT or MKH types to avoid the use of electrolytic ones in the signal path. Network R_1-C_1 limits the bandwidth of the input signal to minimize the likelihood of intermodulation distortion in the amplifier.

Network R_6-C_8 between pins 8 and 11 limit the bandwidth of the differential input amplifier. Capacitors C_5, C_6, and

1

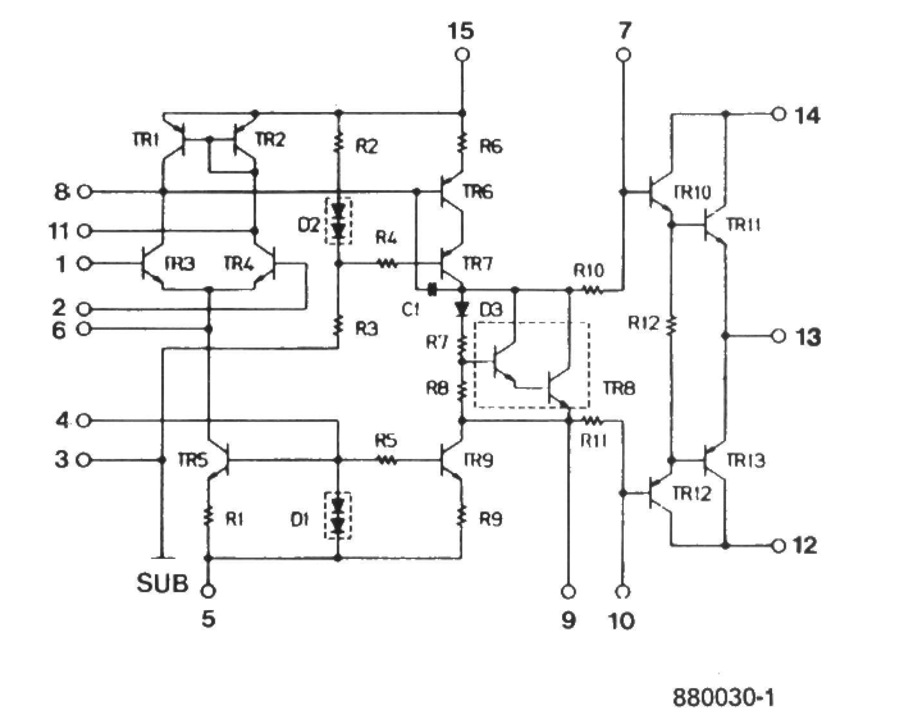


Fig. 1. Circuit diagram of the Sanyo STK series output amplifier module.

Table 1.

Type	No. of pins	Max. values U_B	Max. values T_B	Recommended values U_B into R_L = 8 Ω	Recommended values Gain A_v	$P_{o(max)}$ into 8 Ω	THD for $P_{o(max)}$ = 50 W: THD f = 20 Hz ... 20 kHz, A_v = 26 dB	THD f = 20 Hz ... 20 kHz, A_v = 40 dB	$P_{o(max)}$ into 4 Ω f = 1 kHz
		V	°C	V	dB	W	%	%	W
STK 4036XI		±53.5	125	±37.0	26~45	50	0.003	0.008	55
STK 4038XI		±58.0	125	±40.0	26~45	60	0.003	0.008	60
STK 4040XI	15	±63.0	125	±43.5	26~45	70	0.003	0.008	70
STK 4042XI		±67.0	125	±46.5	26~45	80	0.003	0.008	80
STK 4044XI		±74.0	125	±51.0	26~45	100	0.003	0.008	100
STK 4046XI		±80.0	125	±55.0	26~45	120	0.003	0.008	120
STK 4048XI	18	±87.0	125	±60.0	26~45	150	0.003	0.008	150

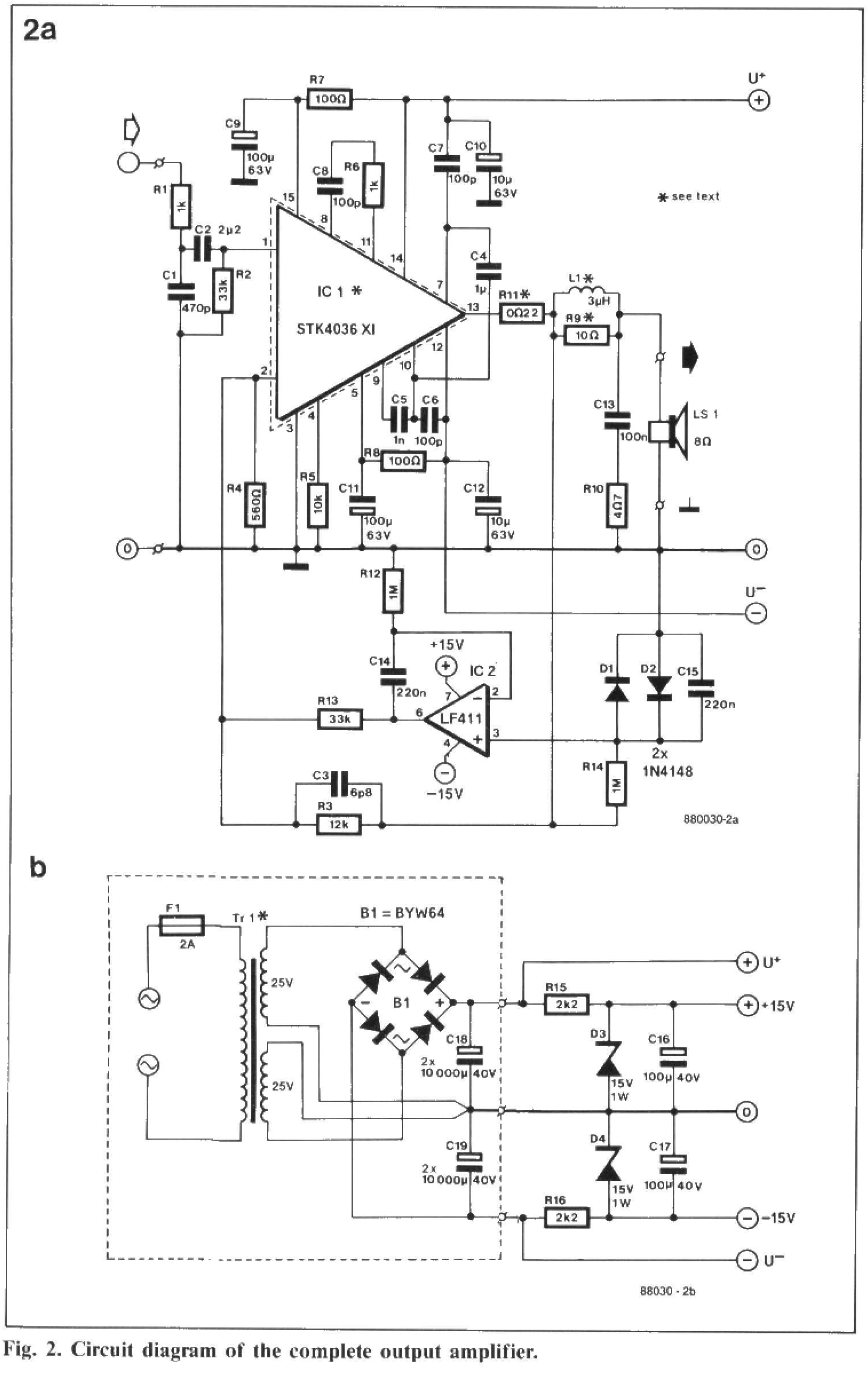


Fig. 2. Circuit diagram of the complete output amplifier.

C_7 further limit the frequency response of the module.

Resistor R_{11} forms a common emitter resistance for the output transistors. Normally, each of the push-pull halves has its own emitter resistance, but Sanyo has chosen a different approach.

Inductor L_1, wound on resistor R_9, prevents excessive currents with capacitive loads. Boucherot network R_{10}-C_{13} ensures that the output stages remain properly loaded at high frequencies, since the loudspeaker impedance then rises sharply.

The power supply is of conventional design which needs no further explanation.

Tests on a couple of prototypes gave excellent results as can be seen from Table 2.

The design uses three identical circuits based on a 50-watt module, fed from a common power supply. It is, of course, possible to use lower rated modules for the mid- and high-frequency output stages, but these would then need a separate power supply, which makes the design more expensive.

Cross-over network

The cross-over filter is identical to that in Ref. 2, but its circuit diagram is reproduced here for convenience's sake. It should be noted that the values of the components give change-over points at 370 Hz and 3200 Hz.

Protection circuit

The protection circuit is very nearly identical to that in Ref. 3, but its circuit diagram is reproduced here for convenience's sake. Compared with the original circuit, two components have been added: a resistor and a diode in series between the junction of R_{16}-S_1 and pin 13 of IC_3 (N_9). These additional components ensure that the circuit operates immediately after a reset (the original circuit delayed this until a new audio signal had been input).

Furthermore, the temperature monitor,

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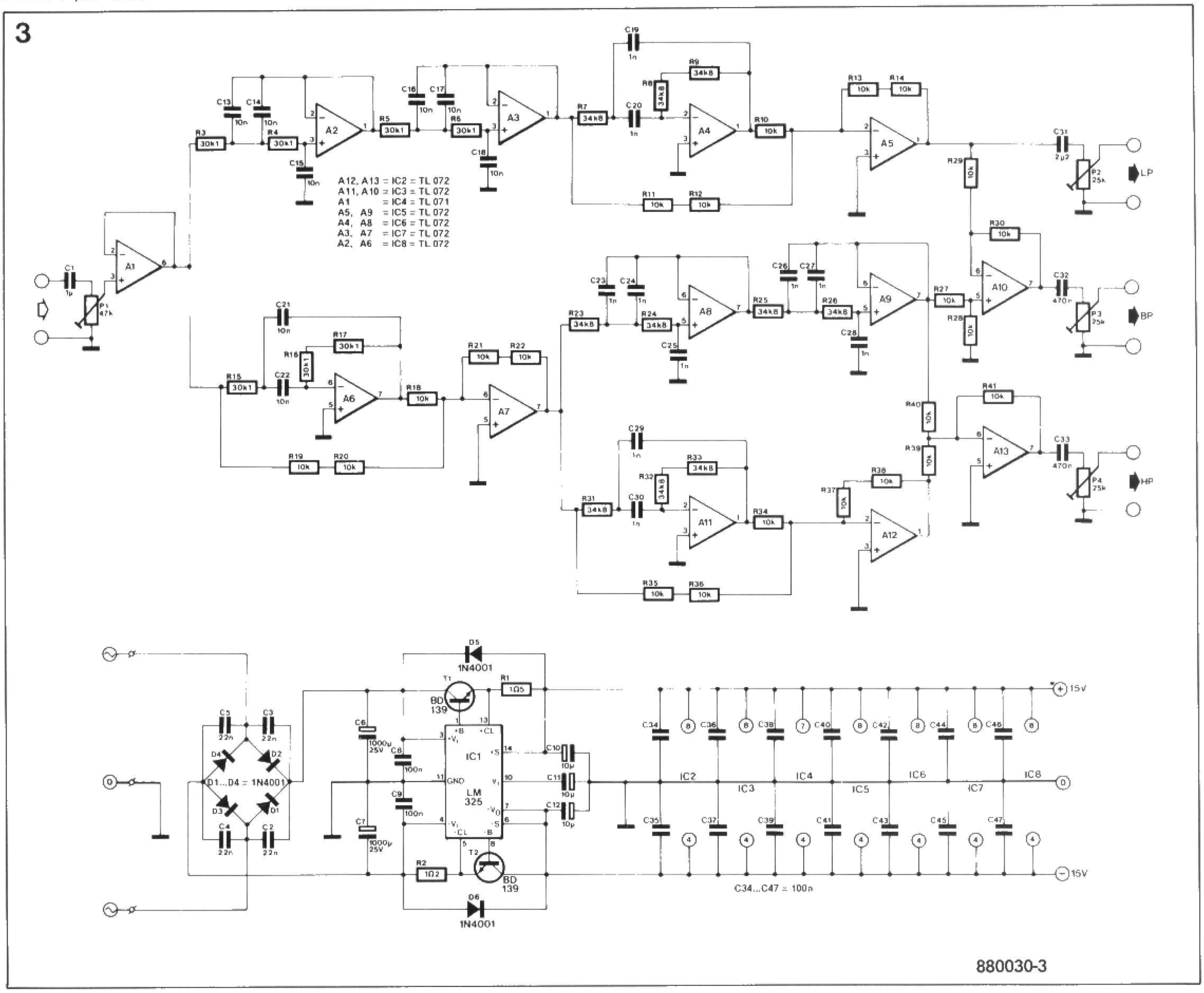

Fig. 3. Circuit diagram of the phase-linear cross-over network.

IC_{11}, of the original circuit has been omitted, since the modules have such a large heat sink that overheating is for all practical purposes impossible.

Otherwise, the monitoring circuits control virtually everything in the amplifier: as soon as a signal appears at the input, the supply is connected to the output stages. In the absence of a signal for more than five minutes, the supply is switched off again. Also, during normal operation, the DC setting of each output stage is monitored separately.

Combining the circuits

First, of course, all printed circuit boards should be populated. The board for the output amplifiers is shown in Fig. 5. Inductor L_1 consists of 3 layers of 10 turns each wound onto R_9 from 1 mm diameter enamelled copper wire. Where higher wattage modules 4046XI or 4048XI are used, resistors R_{11a} to R_{11c} should be added, because these modules have parallel connected output transistors. With modules 4036XI to 4044XI only resistor R_{11} is required. The modules should be mounted last of all: do not shorten their pins.

When populating the filter board, take care to solder all resistors in their correct positions: 1% metal film resistors often give problems in this respect. It is advisable to check each of these resistors with an ohmmeter.

The addition of the resistor and diode on the protection board should not create any problems.

When the five boards have been completed, they should be fitted in a suitable enclosure. That for the prototypes enabled it to be fitted at the rear of the loudspeaker enclosure. This ensured that the connecting wires between loudspeakers and output stages were kept as short as possible. It is, of course, also possible to install all circuits at the bottom inside of the loudspeaker enclosure. The wiring diagram for the entire electronic part of the loudspeaker system is shown in Fig. 6. Note that there is only one central earthing point: it is important to stick to that to avoid earth loops between the screened cables. The screens of these cables should be connected to earth at only one side.

Good care should be taken, as always, to ensure that any mains-carrying parts and wiring should be well insulated.

The output modules may be screwed to a large heat sink without insulation, but with copious use of heat conducting paste.

The input socket should be isolated from the box.

If, as proposed, the boards of the filter and protection circuits are mounted above one another, they should be shielded from each other by a suitable metal plate. This is necessary to prevent the protection circuits causing interference in the filter (this happened in the prototype, and it took a day to find the culprit).

Once everything is completed, the system should be tested without the loudspeakers. When the mains is switched on, the reset button of the protection circuits must be pressed to start these circuits.

If everything is found in order (particularly, there should, of course, be no DC

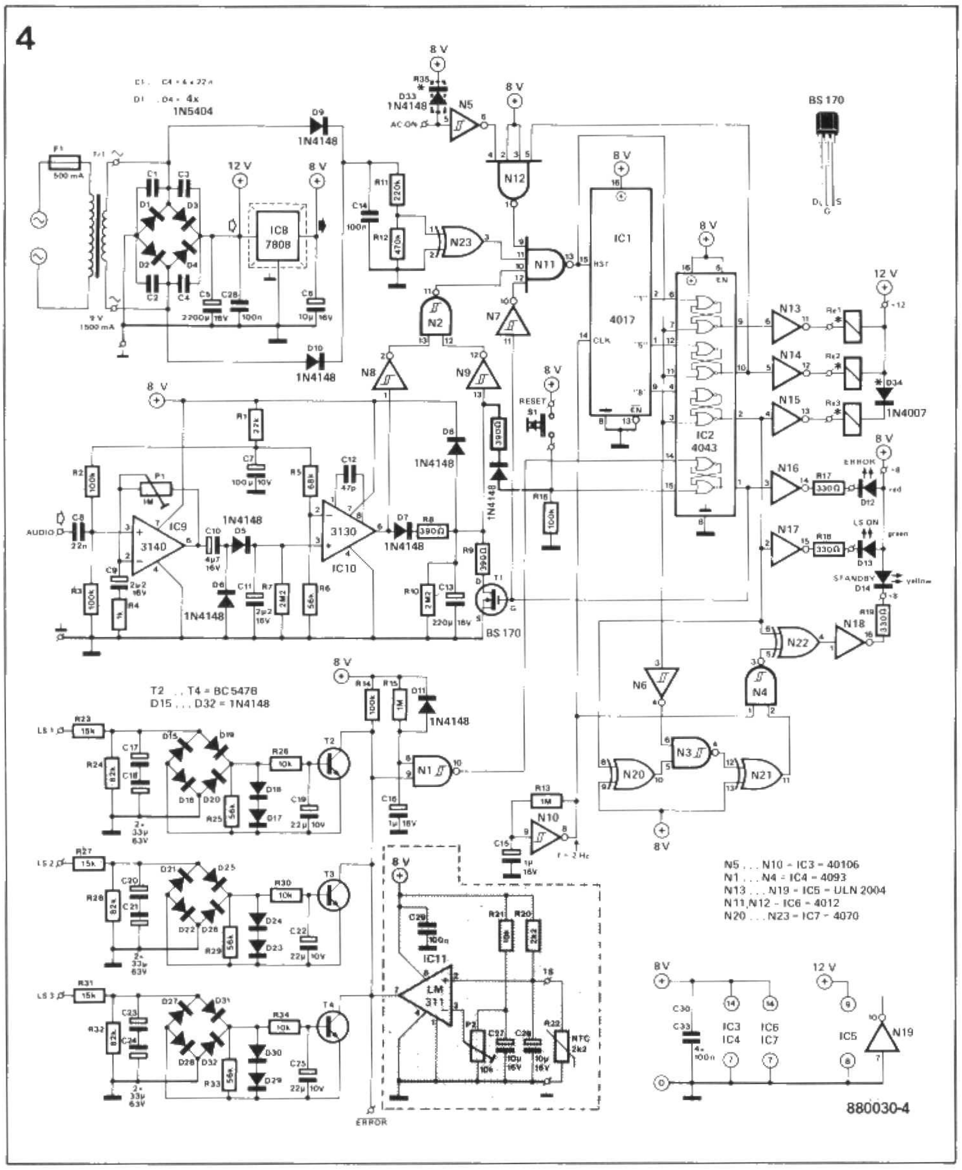

Fig. 4. Circuit diagram of the protection circuits.

Parts list
(for each of the 3 output amplifiers)

Resistors:
R_1;R_6 = 1k0
R_2;R_{13} = 33 k
R_3 = 12 k
R_4 = 560 R
R_5 = 10 k
R_7;R_8 = 100 R
R_9 = 10 R/1 W
R_{10} = 4R7
R_{11} = 0R22; 5 W
R_{12};R_{14} = 1 M
R_{15};R_{16} = 2k2

Capacitors:
C_1 = 470 p
C_2 = 2μ2 (MKT)
C_3 = 6p8
C_4 = 1μ0 (MKT)
C_5 = 1n0
C_6;C_7;C_8 = 100 p
C_9;C_{11} = 100 μ; 63 V
C_{10};C_{12} = 10 μ; 63 V
C_{13} = 100 n
C_{14};C_{15} = 220 n
C_{16};C_{17} = 100 μ; 40 V
C_{18};C_{19} = 2 × 10,000 μ; 40 V

Semiconductors:
D_1;D_2 = 1N4148
D_3;D_4 = 15 V; 1 W; zener
IC_1 = STK-4036XI
IC_2 = LF411
B_1 = BYW64

Miscellaneous:
Mains transformer: 2 × 25 V; 4.5 A secondary
Re_1;Re_2 = 12 V; 1 make (contact 250 VAC; 5 A)
Re_3 = 12 V; make (contacts 250 VAC; 6 A)
Fuse, 2 A, delayed action
Fuse, 0.5 A, delayed action
Mains switch, DPST
PCB 880030 (3×)
PCB 85120
PCB 87109

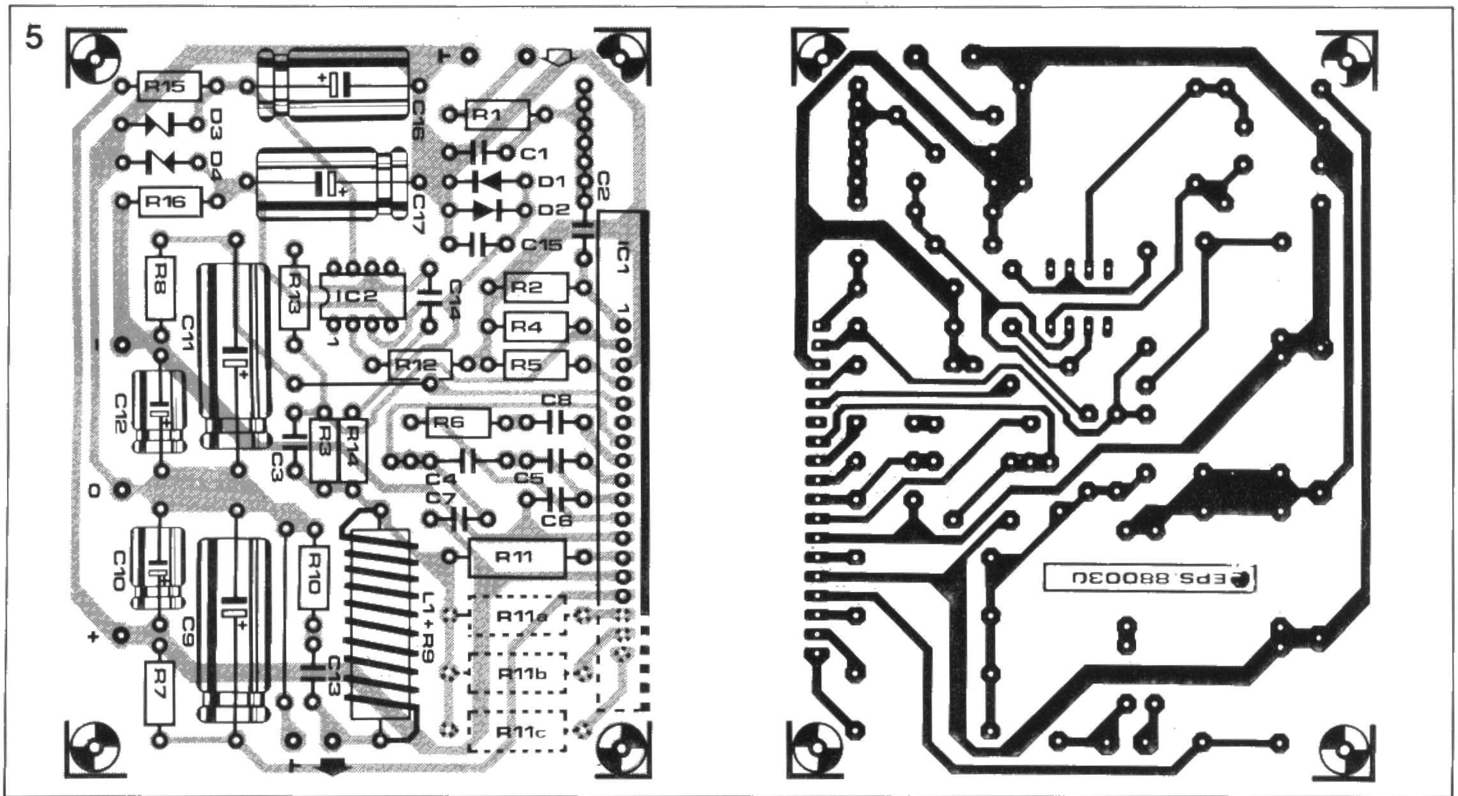

Fig. 5. Printed circuit board of the output amplifier.

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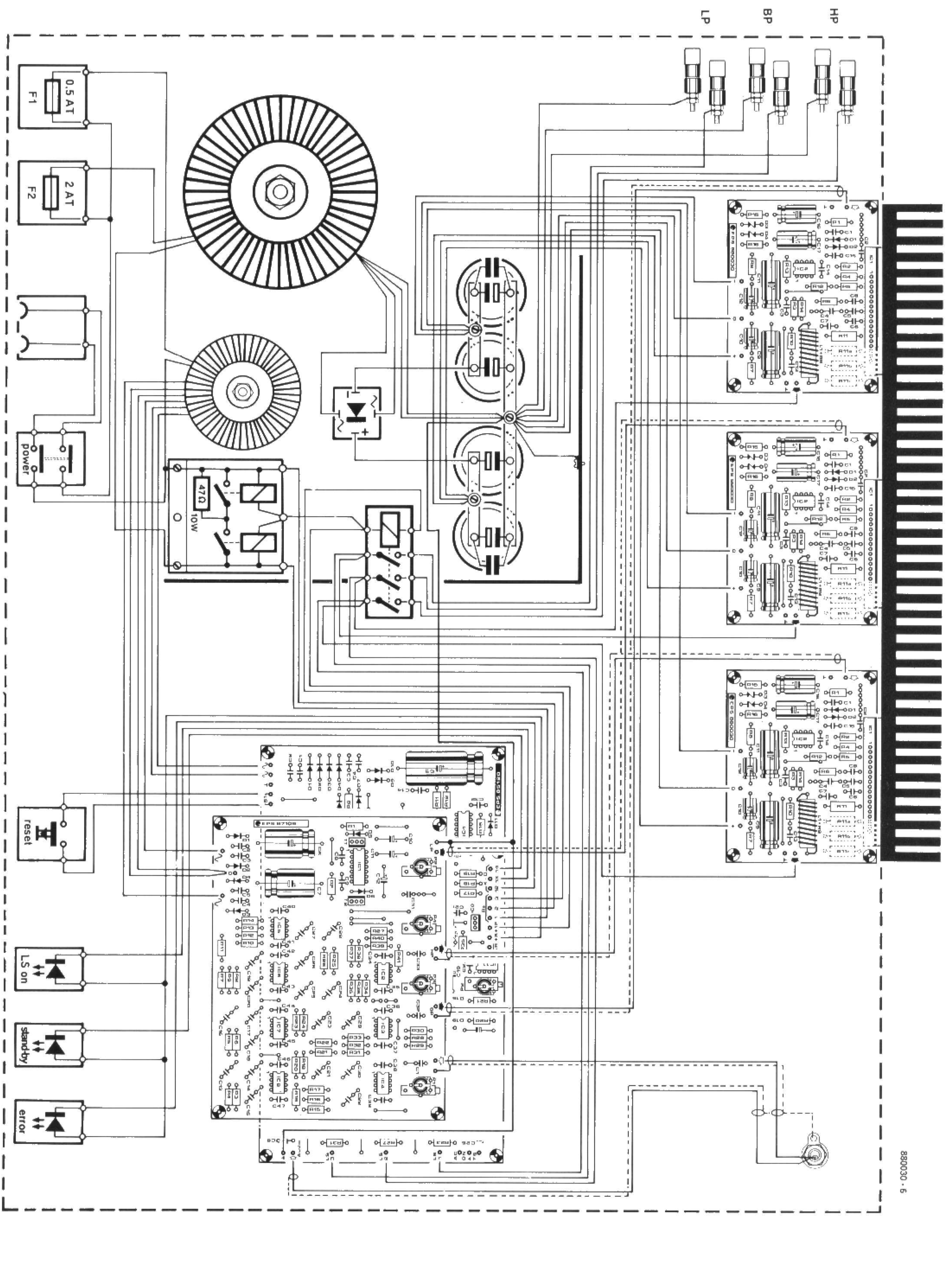


Fig. 6. Wiring diagram of the electronic part of the loudspeaker system.

Table 2.

Prototype measurements

Power output (R_L = 8 Ω)	: 50 W
Signal-to-noise ratio	: > 110 dB
Bandwidth (P_o = 1 W)	: 3 Hz . . . 150 kHz (−3 dB)
THD (P_o = 1 W)	: < 0.005% (1 kHz)
	< 0.03% (20 Hz . . . 20 kHz)
Input sensitivity	: 1 V_{rms}
Output impedance	: < 0.02 Ω (20 Hz . . . 20 kHz)

on the output terminals), the output amplifiers may be connected to the output terminals (but not yet to the loudspeakers).
The operating sensitivity of the protection circuits is set by P_1.
All potentiometers on the filter board are then set for minimum attenuation. Note that P_1 and P_3 should be turned in the opposite direction from P_2 and P_4.
Next, the output signal at the BP terminal should be set for an attenuation of 1 dB by P_3, and that at the HP terminal for an attenuation of 2 dB by P_4. This is most conveniently done with the aid of an audio generator and AC voltmeter, but it may also be done with the aid of an ohmmeter: set the wiper of P_3 to 0.9 of the total resistance, and that of P_4 to 0.8 of the total resistance. These ohmmeter aided settings should, of course, be carried out with the mains switched off.
Finally, the loudspeakers may be connected: they should all be in phase.
The reproduction from the active system was noticeably better than that of the passive version of last month. This is particularly so at the lower and the higher frequencies.

References:

1. *Uniphase Loudspeaker System*, *Elektor Electronics*, March 1988, p. 36.
2. *Active Phase-linear Cross-over Network*, *Elektor Electronics*, September 1987, p. 61
3. *Audio-controlled Loudspeaker Monitor*, *Elektor Electronics*, December 1985, p. 55.
4. *Top-of-the-Range Preamplifier*, Part 3, Table 4, *Elektor Electronics*, January 1987, p. 35.

AUDIO & HI-FI NEWS

Voice Coil

Readers interested in loudspeaker manufacture and design are advised that since last November there is a new Newsletter for the Loudspeaker Industry, called *VOICE COIL*.
Aimed primarily at the loudspeaker industry, the newsletter is designed to be a useful information resource of current and important data of interest to members of the manufacturing community. *Voice Coil* will contain information on new products, literature, research papers, computer software, patents, marketing research, as well as a free classified section.
Voice Coil is published monthly by

Audio Amateur Publications
P.O. Box 576
Peterborough
New Hampshire 03458-0176
U.S.A.

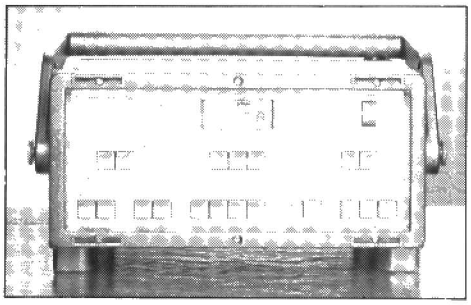
Titanium-dome tweeter kit

Metal dome tweeters are becoming increasingly popular and Wilslow Audio now offer a titanium-dome tweeter upgrade kit which suits most speakers that were originally fitted with one-inch soft-dome units. The kit is suitable for replacing tweeters that have a sensitivity of up to 91 dB (normal: 89 to 90 dB).
A cleaner, crisper response is claimed, and the increased power handling resulting from the ferrofluid cooling of the voice coil makes this a useful upgrade for pre-CD speakers now being used with a CD-based system.
The kit includes a constant-impedance level control with a flush mounting escutcheon which fits neatly into the baffle board. The existing cross-over network needs no modification.
The kit, for a pair of speakers, is priced at £41.90, incl. VAT, plus £2.50 p&p, and is available from

Wilmslow Audio Limited • 35-39 Church Street • WILMSLOW SK9 1AS • Telephone (0625) 529599.

Portable sound intensity analyser

Bruel & Kjaer's new Type 4433 Sound Intensity Analyser is a portable and simple-to-use solution to many different noise measurement problems. It allows accurate on-site operation without inconvenient cables.

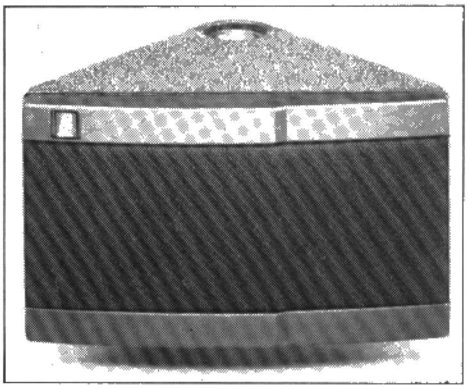


The 4433 measures the net acoustic energy flow by the two-microphone pressure gradient technique. It is able to locate and discriminate between sound sources, giving a complete acoustic picture even in conditions of high-level background noise. This makes it possible to make measurements in situ that previously required an anechoic room.

Bruel & Kjaer (UK) Ltd • Harrow Weald Lodge • 92 Uxbridge Road • HARROW HA3 6BZ • Telephone 01-954 2366.

AR introduces Environmental Partners

Following on from the success of AR's design-award-winning Powered Partners



and styled by the same international design house to match the AR electronics range, the new AR Environmental Partner packs a lot of speaker into a small package.
The Environmental Partner is a full-range loudspeaker system with a four-inch polypropylene-coned woofer and a 1.25-inch liquid-cooled tweeter in a sleek, wedge-shaped cast aluminium case, finished in smart scratch-resistant black.

Teledyne Acoustic Research • High Street • Houghton Regis • DUNSTABLE LU5 5QJ • Telephone (0582) 867777.

The Real Hi-fi Story

Written by hi-fi and music writer Peter Herring, this booklet demystifies the whole business of buying hi-fi equipment. It has been produced by the British Audio Dealers Association (BADA), the Federation of British Audio, and a selection of importers of quality hi-fi (known as 'The Friends').
Any readers interested in buying hi-fi can obtain a free copy of the booklet (normally priced at £2.50) by writing to:

The Sound Advice Centre
40/41 Great Castle Street
LONDON W1N 7AF

TUNEABLE PREAMPLIFIERS FOR VHF AND UHF TV

The second, final, article on remote-tuned, masthead mounted, RF preamplifiers deals with high-performance aerial boosters for the VHF and UHF TV bands. These circuits give a considerable improvement in reception compared to run-of-the-mill wideband aerial boosters. Connected to a good directional aerial, they are ideal for picking up signals that are normally noisy, or impaired by cross-modulation from strong nearby transmitters. But TV DXers need not be told . . .

The preamplifiers described can be built by anyone with reasonable experience constructing electronic circuits. Special care has been taken in the designs to minimize the necessary work on inductors, while alignment is straightforward, because in most cases it only entails setting a direct current. The amplifiers are built on high-quality printed circuit boards available through our Readers' Services, and are tuned and powered from the master tuning/supply unit described last month.

VHF preamplifier: circuit description

What is commonly referred to as the VHF TV band is roughly the frequency range between 45 and 68 MHz (Band 1), but also that between 175 and 225 MHz (Band 3). Band 2 is the FM radio broadcast band. It is important to note here that the above band limits are given as guidance only, because they are set differently in many countries and regions in the world. This also goes for the TV system used (PAL, SECAM, NTSC, positive/negative video, horizontal/vertical polarization, number of lines, channel assignment, frequency of the sound subcarrier, etc.). In the United Kingdom, Band 1 is currently allocated to military communications; the former TV services in that band have been transferred to UHF in 1983.

The circuit diagram of the VHF preamplifier is given in Fig. 1. Unbalanced (50..75 Ω) or balanced (200. . .300 Ω) cables are connected to input inductor L_{1A}. The aerial signal is coupled inductively to the base of low-noise RF transistor T_1 via L_{1B} and C_1, which is connected on a tap for impedance matching. The input inductor, L_1, is tuned to the relevant TV channel by the series capacitance formed by varactors D_3-D_4. The voltage at the junction of these variable capacitance diodes is the voltage on the downlead cable minus 8.2 V. The junction capacitance of a varactor decreases with the reverse voltage on it, so that the lowest value of the downlead voltage, 9 V, causes the input inductor, L_1, to resonate at the lowest frequency, i.e., the preamplifier is tuned to the lowest TV channel.
The amplifier can be set up for operation in TV Band 1 or Band 3 simply by fitting the appropriate inductor in position L_1 (this will be reverted to under *Construction*).
Choke L_3 forms a high impedance for the amplified RF signal on the downlead coax cable, and feeds the tuning/supply voltage to series regulator T_2 and zener-diode D_1. The function of these components is similar to IC_1 and D_3 in the FM-band preamplifier described last month. The forward drop across LED D_1 is fairly constant, and provides the reference voltage at the base of regulator T_2. Preset P_1 makes it possible to set the optimum collector current for the RF amplifier transistor, T_1. RF signals at the base and collector of the BFG65 are blocked from the bias voltages by chokes L_2 and L_4, respectively. Gain of the preamplifier is fairly constant at about 18 dB, both in Band 1 and Band 3. The noise figure was not measured, but should be of the order of 1. . .2 dB, i.e., considerably lower than almost any conventional wideband aerial booster.

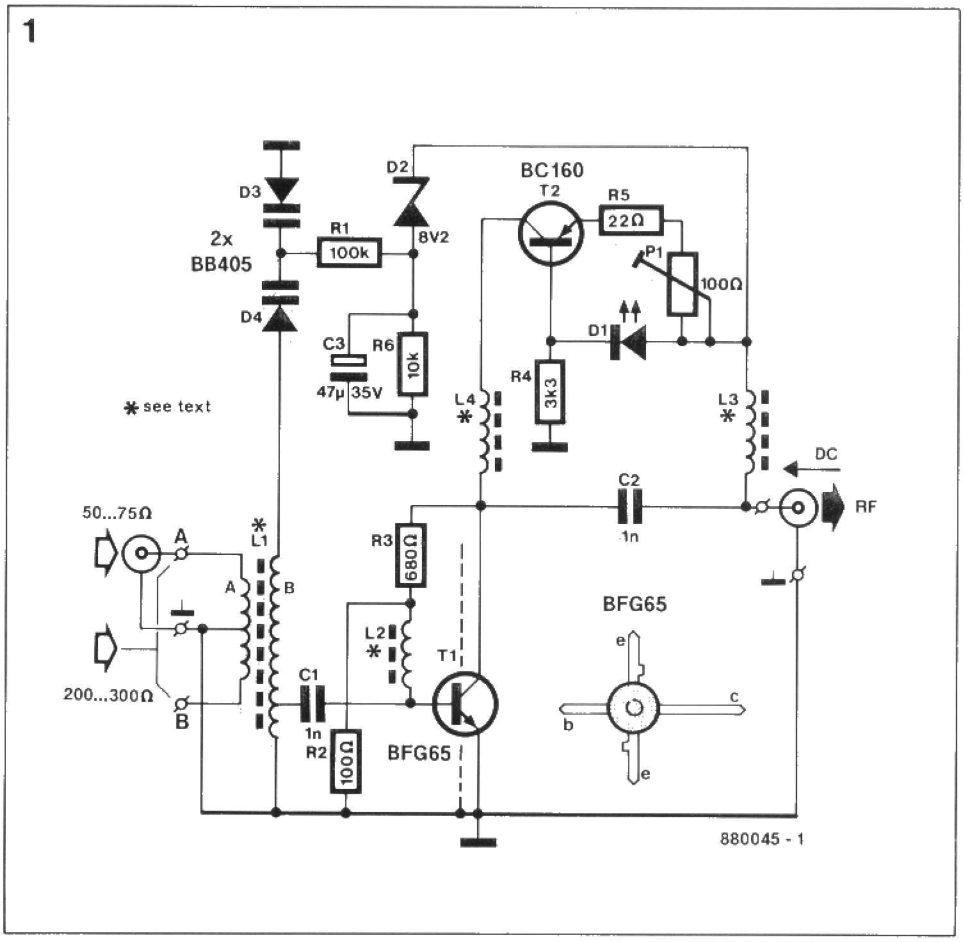


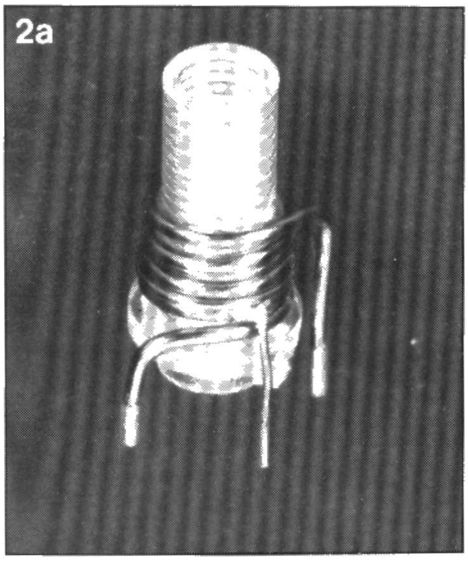
Fig. 1. Circuit diagram of the low-noise, remote-tuned, preamplifier for VHF TV Band 1 or 3.

VHF preamplifier: construction

Commence the construction with making L_1 as required for the relevant frequency range (note that this may extend beyond the indicated band limits). Do not skip the constructional hints in the following paragraphs if you intend to build the Band 1 version of the preamplifier.

Band 3 (175—225 MHz):

1. Close-wind L_{1B} as 4 turns ∅1 mm (SWG19) enamelled copper wire around a ∅6 mm plastic former. Use a miniature screwdriver to spread the turns evenly at about 1 mm. Study the position of the inductor on the board, and bend the wire ends towards the holes provided. Use a scalpel or sharp hobby knife to remove the enamel coating on the wire ends over a length of about 3 mm. Pretin the connections, scratch off residual solder resin, and pretin once more. Check for a smooth, tinned, surface.



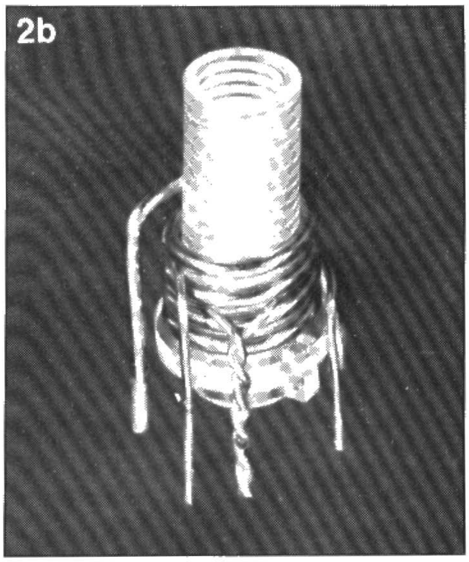


Fig. 2. Close-up photographs showing inductor L_1 in the VHF Band 3 preamplifier. Fig. 2a: seen from the side of L_{1B}; Fig. 2b: seen from the side of L_{1A} (note the tap made in twisted wire).

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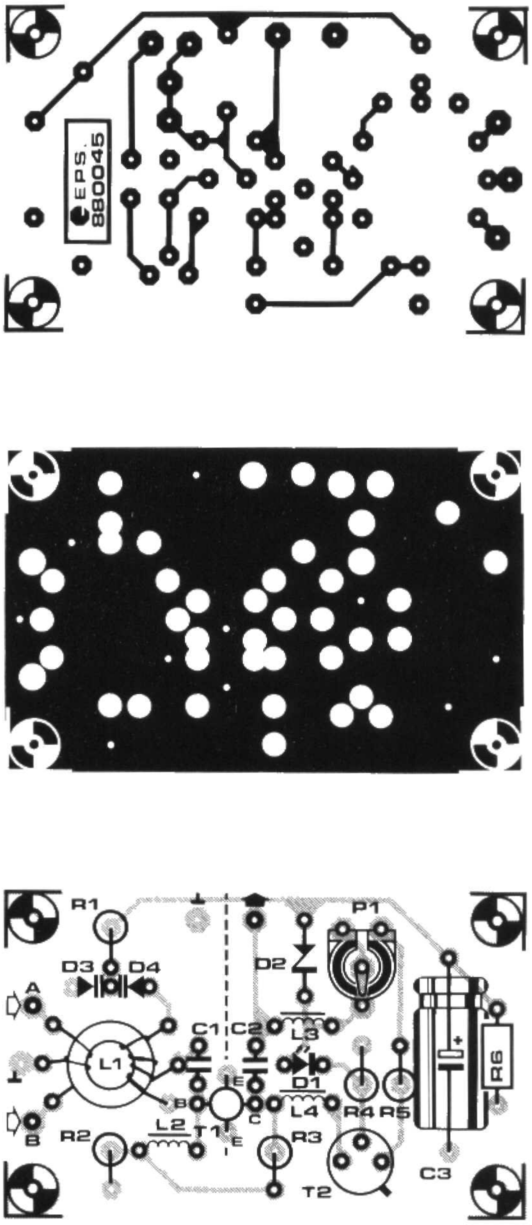


Fig. 3. The printed circuit board for the VHF Band 1 or 3 preamplifier.

Parts list

VHF PREAMPLIFIER. CIRCUIT DIAGRAM: FIG. 1.

Resistors (±5%):

R_1 = 100K
R_2 = 100R
R_3 = 680R
R_4 = 3K3
R_5 = 22R
R_6 = 10K
P_1 = 100R preset H

Capacitors:

C_1;C_2 = 1n0 miniature ceramic plate; pitch: 5 mm.
C_3 = 47μ; 35 V; axial

Semiconductors:

D_1 = red LED
D_2 = zenerdiode 8V2; 400 mW
D_3;D_4 = BB405
T_1 = BFG65
T_2 = BC160

Inductors:

Winding data and materials are stated in the text.

Miscellaneous:

PCB Type 880045 (see Readers Services page).

2. Locate the position of the tap on L_{1B} at 1 turn from the ground connection. Carefully scratch off the enamel locally, pretin the small copper area, and connect a short length of ∅0.5 mm (SWG25) enamelled copper wire. Place the plastic former plus inductor onto the PCB, and bend the tap wire towards the relevant hole. Do not solder any connection as yet. Make sure that the tap does not create a short-circuit between the turns of L_{1B}.
3. The input coupling inductor, L_{1A}, is wound as 2 turns ∅0.5 mm (SWG25) enamelled copper wire, with a tap at the centre. Wind this inductor in between the turns of L_{1B} to assure the necessary inductive coupling. Insert the wire below the turn of L_{1B} that has the tap on it. Wind the wire upwards into the free space between the turns of L_{1B}, until it is opposite the connections of L_{1B}. Draw out about 4 cm of the wire, fold it back again towards the former, and wind the last turn upwards into L_{1B}.
4. Use precision pliers to twist the 2 cm long wire pair that forms the tap on L_{1A}. Hold the end of the wires in the pliers, and carefully revolve these in your hand until the wires cross practically at the body of the plastic former.
5. Place the former with the inductors on it onto the PCB, and revolve both L_{1A} and L_{1B} until all six wires can be inserted in the respective holes. Scratch off the enamel coating from the tap and the ends of L_{1A}, pretin, clean again by scratching, and ensure a smooth soldering surface. Press L_{1B} together to lock up the turns of L_{1A}. The final appearance of the completed inductor is shown in the photographs of Fig. 2.

Drill and file the hole that receives the plastic former. Fit the wires of L_1 into the respective holes, and verify correct continuity. Do not use a core in L_1.

Band 1 (45—68 MHz):

For the lower frequency range, L_1 is wound on a Type T50-12 ferrite core (∅12 mm) from Micrometals.

1. Wind L1A as 8 turns ∅0.5 mm (SWG25) enamelled copper wire, with a twisted centre tap created as discussed above.
2. Wind L_{1B} as 20 turns of ∅0.5 mm (SWG25) enamelled copper wire, with a twisted tap at 4 turns from the ground connection.
3. Fit the complete inductor onto the PCB, making sure that the windings remain secure on the ferrite ring.

Chokes L_2, L_3 and L_4 are identical for both versions of the VHF preamplifier. They are wound as 4 turns ∅0.2 mm (SWG36) enamelled copper wire through small ferrite beads (length: approx. 3 mm).

The printed circuit board for the VHF preamplifier is shown in Fig. 3 (note that the component overlay is relevant to the version for Band 1). Completion of the preamplifier should not present problems. Grounded component wires and terminals are soldered at both sides of the board. Coupling capacitors C_1 and C_2 are miniature, plate or disc, ceramic types with a lead spacing of 5 mm. Mount these as close as possible to the PCB surface. Conversely, mount T_2 in a manner that rules out any likelihood of a short-circuit between the TO5 case (which is at collector potential) and the PCB ground surface. Finally, fit a 15 mm high brass or tin metal sheet across T_1 as indicated by the dashed line on the component overlay.

The UHF preamplifier: circuit description.

The circuit diagram of the low-noise, remote-tuned, UHF preamplifier for masthead mounting is shown in Fig. 4. Like the VHF booster, this amplifier is based on the Type BFG65 RF transistor from Valvo (Philips/Mullard), but in this application has tuned input and output circuits. The tuning voltage for varactor pairs D_1-D_2 and D_3-D_4 is obtained as in the FM-band and VHF preamplifiers, namely by subtracting the fixed drop across a zenerdiode from the voltage carried on the downlead coax connected to the master tuning/supply control. The tuning range of the amplifier covers the entire UHF TV band (470—860 MHz). The shaded rectangular blocks in the circuit diagram are straight lengths of silver-plated wire that function as inductors (L_1; L_2).

Balanced aerials or feeder systems with a termination impedance of 200...300 Ω are connected to L_{1B}. This coupling inductor is omitted when the input signal is unbalanced (50...75 Ω). In this case, the centre core of the coax cable is connected direct to a matching tap close to the ground connection (*cold end*) of L_{1A}. Regulator IC_1 ensures that T_1 is fed with a constant supply of 8 V, while P_1 is used for setting the optimum collector current (this can be read on a microammeter connected to test points TP1 and TP2).

The UHF amplifier has a typical gain of 12 dB and, like the VHF version, achieves a noise figure that beats the vast majority of wideband aerial boosters.

The UHF preamplifier: construction

The UHF TV band preamplifier is constructed on the PC board shown in

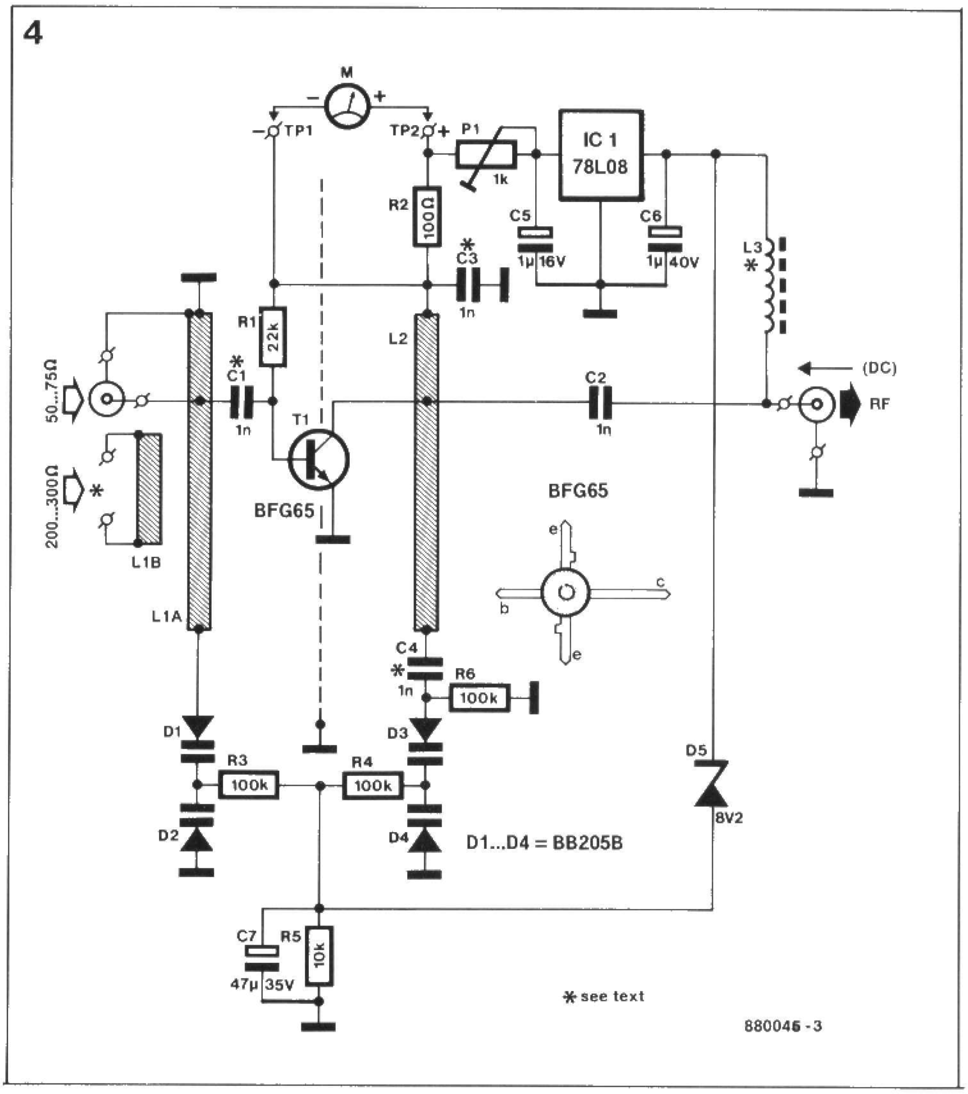


Fig. 4. Circuit diagram of the preamplifier for UHF TV reception.

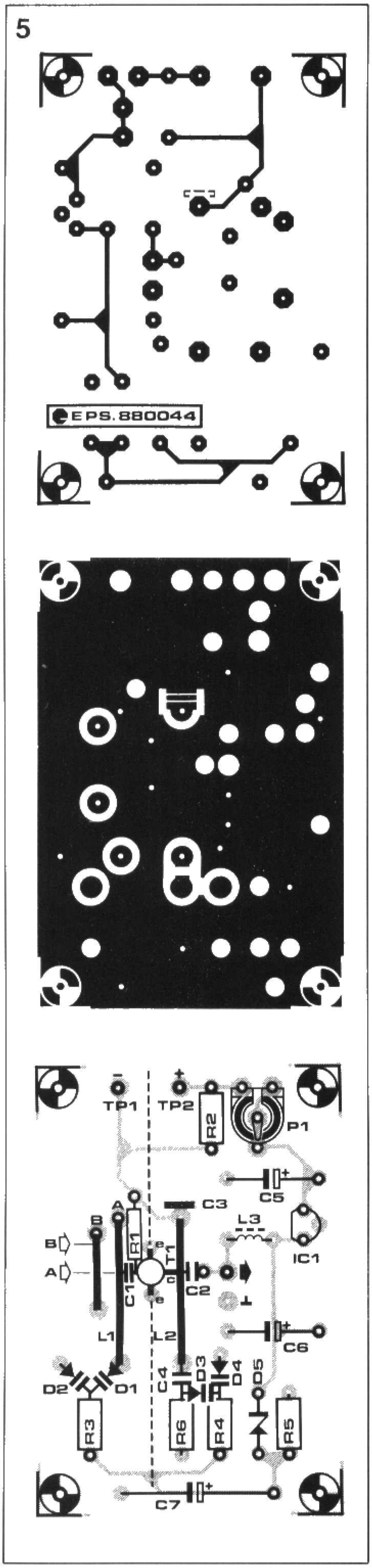


Fig. 5. Track layout and component mounting plan of the PCB for the UHF preamplifier.

Fig. 5. Study the component overlay, and bend L_{1A} (if required), L_{1B} and L_2 to size from ∅1 mm silver plated copper wire (CuAg). Do not solder these inductors in place, however, until they run straight over the full length, and are positioned so that the top of the wire is always exactly 3 mm above the PCB surface. Fit leadless disc or rectangular decoupling capacitor C_3 in the slot provided in the PCB. This (brittle!) capacitor is soldered once at the track side (connection to L_2), and twice at the component side (ground and, again, L_2). Now position the RF transistor, T_1, in between the wire inductors, and solder the 2 emitter terminals direct to the ground surface. Carefully bend the collector terminal upwards, cut it to length, and solder it to the tap on L_2. One terminal of coupling capacitor C_2 is also connected direct to this junction, while the other terminal is secured in a PCB hole—see the photograph of Fig. 6. Bend the base terminal of T_1 upwards, and carefully cut this to a length of about 2 mm. Solder a 1nF SMD capacitor, C_1, in between the tap on L_{1A} and the base terminal. R_1 is also soldered direct to the base junction. Fit a 15 mm high screen across T_1 as indicated on the component overlay.
Wind choke L_3 as 6 turns ∅0.2 mm (SWG25) through a small (3 mm long) ferrite bead. The fitting of the remainder of the components is straightforward,

Parts list

UHF PREAMPLIFIER, CIRCUIT DIAGRAM: FIG. 3.

Resistors (±5%):

R_1 = 22K
R_2 = 100R
R_3;R_4;R_6 = 100K
R_5 = 10K
P_1 = 1K0 preset H

Capacitors:

C_1;C_4 = 1n0 SMD
C_2 = 1n0 miniature plate ceramic.
C_3 = 1n0 leadless ceramic (disc or rectangular).
C_5 = 1μ0; 16 V; axial
C_6 = 1μ0; 40 V; axial
C_7 = 47μ; 35 V; axial

Semiconductors:

D_1 . . . D_4 incl. = BB205B
D_5 = zenerdiode 8V2; 400 mW
IC_1 = 78L08
T_1 = BFG65

Inductors:

Winding data and materials are given in the text.

Miscellaneous:

PCB Type 880044 (see Readers Services page).

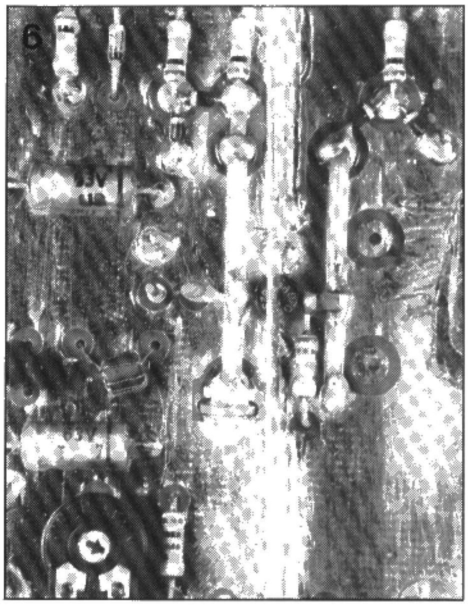


Fig. 6. Top view of the line inductors in the preamplifier for UHF TV.

and should not present problems. Be sure, however, to observe the polarity of the 3 electrolytic capacitors and the 5 diodes!
Figure 7 shows completed prototypes of the VHF and the UHF aerial boosters.

Setting up

The setting up of the preamplifiers merely entails adjusting the collector current of the RF transistor, and finding out which value of the tuning voltage corresponds to a particular TV channel.

VHF preamplifier:

Insert an ammeter between the collector of T_2 and L_4. Connect the power supply/tuning unit described last month, and set the output voltage to 20 V. Adjust P_1 for a reading of 5 mA, then verify the presence of about +11 V on the varactor junction. Vary the tuning voltage, and verify that the collector current of T_1 remains constant. The LED will light dimly.
Connect the preamplifier to the aerial and the supply/tuning unit. Also connect the TV set, and set up a tuning scale by marking the channel numbers as a function of the tuning voltage. In the case of the Band 3 preamplifier, the tuning range can be corrected by carefully compressing or stretching the turns of L_{1B}.
The collector current of T_1 is optimized by tuning to a weak transmission, and setting P_1 for minimum noise. This setting is typically found at collector currents between 3 and 10 mA.

UHF preamplifier:

Connect a millivolt meter to TP1 and TP2 as shown in the circuit diagram. Set P_1 for a reading of 500 mV. Make notes of the tuning voltage required for a number of TV channels in the UHF

band, and provide a UHF tuning scale on the master supply/tuning unit.

General considerations

The values stated for the operating current of T_1 are given as a compomise between a low noise figure (low collector current), and high amplification in combination with good intermodulation characteristics (high collector current). The collector current may, therefore, be set to different values to suit the application in question.

As stated in last month's article, there is little point in installing the remote-tuned preamplifiers in any place other than *as near as possible to the relevant aerial*. This is the only way to prevent the attenuation introduced by the downlead coax cable degrading the system noise figure. The preamplifiers described have sufficient gain to bring the system noise figure down to practically the preamplifier noise figure, but only if they are properly aligned and installed. *B*

Readers interested in TV-DXing are advised to contact the British Amateur Television Club • Mr Dave Lawton G0ANO • "Grenehurst" • Pinewood Road • High Wycombe • Bucks HP12 4DD.

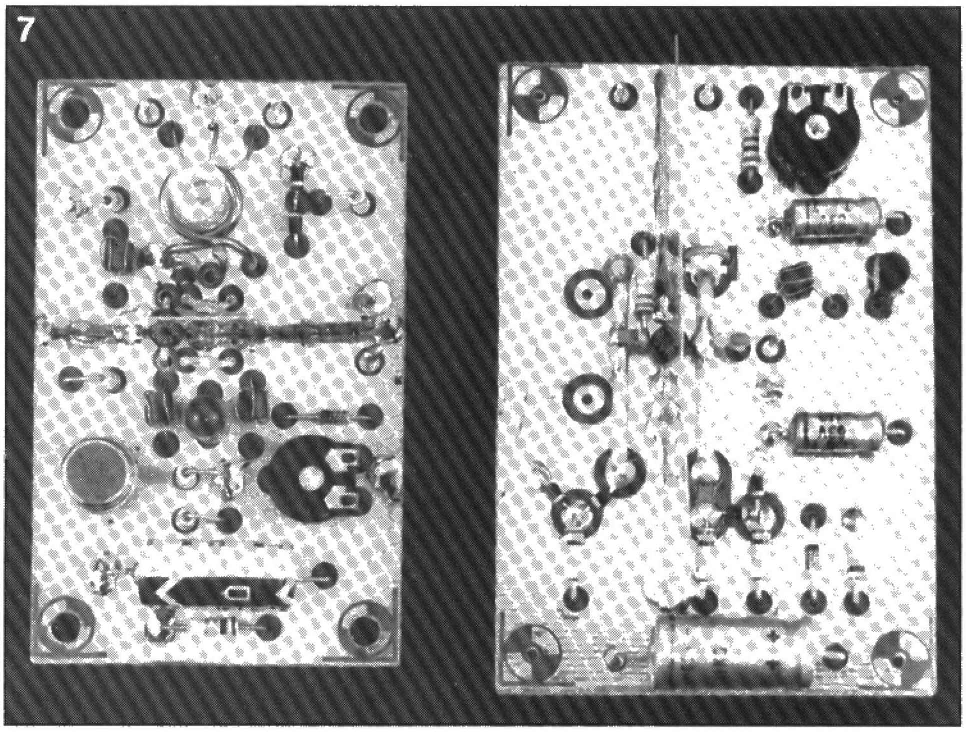


Fig. 7. Prototypes of the VHF preamplifier (left; Band 3 version), and the UHF preamplifier (right).

RADIO COMMUNICATIONS FOR THE FUTURE

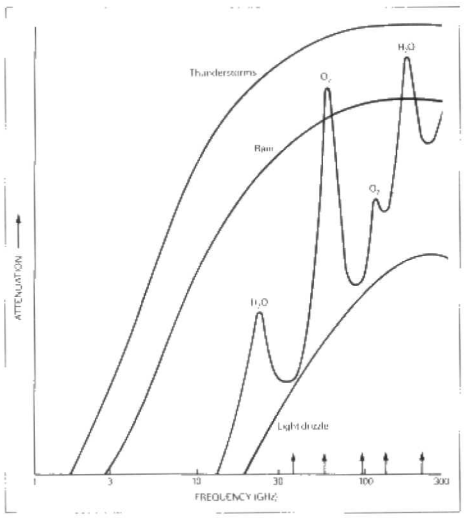
by Dr. Chris Gibbins, Rutherford Appleton Laboratory

Overcrowding of the radio spectrum is severely restricting the reliability and information-carrying capacity of existing communications systems. But moving to higher frequencies, where there is more room, brings a different set of problems to do with the atmosphere and weather. Research at the UK Science and Engineering Research Council's Rutherford Appleton Laboratory is compiling valuable data for the design of systems for the future, exploiting frequency bands that are so far little used but for which the necessary technology is already available.

A massive expansion in radio communications over recent years has generated an ever-increasing demand for more channels, and those channels are having to carry more and more information, be it voice, television or other kinds of data. The net result is that the radio spectrum, a restricted resource, is fast becoming overcrowded. This creates problems of interference between adjacent channels (as anyone who listens to short-wave radio, especially at night, will know well) with reduced reliability. There is an additional side-effect of such overcrowding: the bandwidth available to each channel, which determines the amount of information that can be transmitted, is severely limited. That in itself restricts both the capacity and the reliability of communications systems.

Millimetre waves

A remedy for these problems is to be found in exploiting higher and higher frequencies, made possible through the development and availability of new technologies. Communications now extend well into the microwave region of the electromagnetic spectrum (frequencies up to 30 GHz) and even beyond



Attenuation of microwave and millimetre-wave radio signals by the Earth's atmosphere at sea level. Molecular attenuation is present all the time and is produced by water vapour (H_2O) at 22 and 183 GHz and by oxygen (O_2) at 60 and 119 GHz; there are many more of these 'absorption lines', mainly from water vapour, at even higher frequencies. The range of the highly variable attenuation caused by rain is shown by three representative curves for light drizzle, typical rain and intense thunderstorms. The arrows at the bottom indicate the frequencies at which the Rutherford Appleton Laboratory is making measurements.

into the millimetre-wavelength region (frequencies from 30 to 300 GHz). These regions of the spectrum are still relatively uncrowded, particularly at the higher frequencies, and the bandwidths available are so large that they open up the possibility of new communications channels with a capacity for carrying huge amounts of information.

But use of the microwave and millimetre wave regions of the spectrum for communications brings an additional set of problems not met with at lower frequencies. The Earth's atmosphere starts to interact with the radio waves, resulting in attenuation of the signals which must be taken into account in the design of systems. There are two distinct and quite different effects, which are shown in the first diagram. First, the molecules of oxygen and water vapour in the atmosphere absorb radiowaves at certain characteristic frequencies. This is known as resonant absorption. They re-radiate them isotropically, that is, equally in all directions, a fraction of a second later; this means that the signal is attenuated through the loss of directivity and coherency. The second effect is that raindrops, hail and snow scatter the signals, thereby attenuating it still more. This effect is non-resonant and increases with increasing frequency, as the wavelength decreases and becomes comparable with the sizes of raindrops; at that point the scattering process is most efficient and signal attenuation is greatest. The first effect, molecular absorption, is present all the time, and changes only slowly with varying temperature, pressure and humidity. A great deal of research has been undertaken into this phenomenon and the effects of molecular absorption can now be predicted fairly accurately. So the designer of communications systems can take reasonably accurate account of attenuation by oxygen and water vapour when assessing the overall performance of microwave and millimetre-wave links.

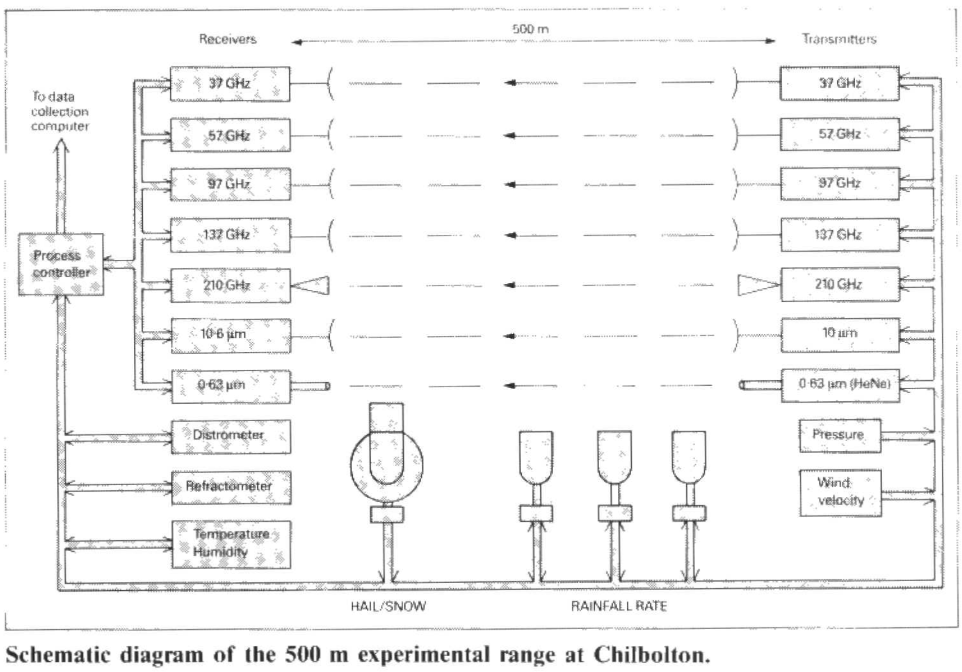
Fade margin

Signal attenuation by rain and other forms of precipitation, however, presents a quite different problem. Precipitation is a highly variable phenomenon, changing both in time, space (that is, geographic location) and intensity. This makes it much more difficult to take account of rain attenuation in designing systems. The problem is generally treated statistically instead of by the sort of exact calculation that can be used for molecular attenuation. The systems designer specifies a level of reliability for a particular communications link: for example, the link might be required to provide acceptable voice communication for 99.9 per cent of the time, or acceptable television transmission for 95 per cent. That means the users can tolerate the service being unavailable for 0.1 per cent or 5 per cent of the time respectively. The designer then needs to know what level of signal attenuation will be exceeded on the link for these small percentages of time. This is known as the 'fade margin' which the link must be able to overcome when providing an acceptable signal-to-noise ratio, to achieve the specified level of reliability. This, in turn, has an impact on the transmitter power, receiver sensitivity and the size of the antennas, which in the end affects the overall cost of the system. It is therefore of paramount importance that the systems designer should have available the most accurate information from which to derive the necessary fade margins, to achieve the most reliable and cost-effective design.

Fade margins are not easily calculable and in general tend to be empirically derived from transmission measurements carried out over long periods. A great deal of work has already been done at frequencies up to about 40 GHz, and there are extensive data banks from which the necessary statistical information and service predictions can be derived. For example, the International Radio Consultative Committee (CCIR) at Geneva collates, distils and publishes information of this kind. At higher frequencies, however, there is a marked paucity of data.

Foundation for systems

To provide the necessary information on terrestrial radiowave propagation, the Rutherford Appleton Laboratory has set up an experimental transmission range at its Chilbolton Observatory near Andover, in southern England. This facility, represented schematically in the second diagram, works on a number of links transmitting over a distance of 0.5 km at frequencies of 37, 57, 97, 37 and 210 GHz in the millimetre-wavelength region of the electromagnetic spectrum and at wavelengths of 10.6 μm in the infra-red and 0.63 μm in the visible region. Frequencies of 37, 97, 137 and 210 GHz were chosen as representative of those parts of the spectrum where atmospheric attenuations due to oxygen and water vapour are low; such parts are known as atmospheric 'windows' and hold out the opportunity for cost-effective, widebandwidth communications. The 37 GHz channel can also provide the means for comparing the results from the 500 m range with exten-



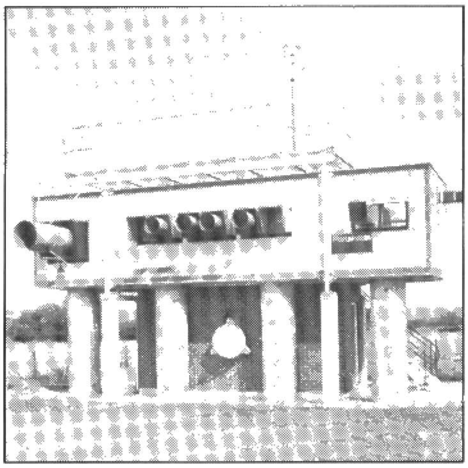
Schematic diagram of the 500 m experimental range at Chilbolton.

sive measurements made at this and lower frequencies at other places and by other workers. The 57 GHz frequency, on the other hand, is near the 60 GHz oxygen absorption band, where very high attenuations of up to 15 dB (decibels) per kilometre occur, which means 97 per cent of the signal is attenuated at a distance of one kilometre from the transmitter and only three per cent remains to be received. Such regions of the spectrum could be used for secure communications, for example where transmission range should be restricted, or for multiple repeated use of a frequency in a dense urban environment, because the atmosphere produces extra isolation between links operating at the same frequency.

In addition to the transmission links, the Chilbolton Observatory compiles a comprehensive set of meteorological data, including measurements of temperature and humidity at a number of places and heights above the ground. There are three rapid-response rain gauges, which measure the rainfall rate at different points along the range at 10-second intervals, while a fourth rain gauge is equipped with heaters to assist the measurement of snow during the winter and hail in the summer. A distrometer measures the distribution of the sizes of raindrops, important in the development of theoretical models to describe rain attenuation; a microwave refractometer measures the refractive index of the atmosphere, which affects the level of scintillation, the name given to small, very rapid fluctuations in the received signal power. The meteorological observations are completed with surface pressure and wind speed and direction.

Outputs from all the links and sensors are coupled *via* an interconnecting computer bus to the main data-collection computer, which records all the measurements on magnetic tape every 10 seconds. Additionally, when attenuation due to precipitation is detected on the range, the outputs from the transmission links are recorded separately at a rate of 100 measurements per second. The datacollection computer also initiates automatic calibrations of the links every 6 hours. All magnetic tapes are subsequently calibrated and verified on a main-frame computer, and the data files put into an archive for anlysis.

The 500 m range, then, is a well instrumented open-air laboratory designed to study in detail the interaction between radio waves and the prevailing weather conditions, by providing comprehensive propagation data for a distance over which meteorological conditions are essentially constant. The range has been in operation for about three years and a substantial data base of propagation data has now been accumulated. It is being used for a variety of studies aimed at a more detailed understanding of the various phenomena which may affect the reliability of communications systems, and providing the statistical information required by systems designers.



The transmitter cabin at Chilbolton. Hoods keep rain off the windows through which the signals are transmitted. The transmitters are mounted on benches supported independently from ground, inside the four concrete pillars. This prevents vibrations in the cabin affecting the equipment. The anemometer and vane mounted on top of the cabin measure wind velocity.

Two main analyses

The data base is being extensively analysed in two different ways. Detailed studies are being made of individual events, such as particular rain storms, snow storms, fogs and so on, to learn more about the way radio waves propagate through such phenomena. From such studies it will be possible to develop more detailed and accurate theoretical descriptions than so far exist of the way various kinds of precipitation and so forth interact with radio waves. These theoretical models, as they are generally known, can then be used to predict what may happen on proposed new communications links in areas where little, if any, propagation or metereological data exist. The second mode of analysis is aimed at providing the kind of statistical data necessary for the most cost-effective design of new communications systems, and to provide a statistical data base for testing and validating the prediction techniques being developed.

Analyses based on individual events are classified according to the type of event, for example rain, snow, hail, fog or scintillation. Extensive studies on rain already indicate a general overall agreement both with similar studies conducted elsewhere and the theoretical models which so far exist, such as those recommended by the CCIR. Nevertheless, certain significant differences have been found, which may possibly be attributed to the differences in climate between southern England and the places where other studies have been made. Understanding such climatological differences is very important in being able to develop prediction models if they are to be applied to any place on Earth. We feel that our work will help considerably in achieving this. Attenuations produced by rain vary considerably, of course, because they depend on the features of the rain. Light drizzle may attenuate the signals by only a few per cent over the 500 m range, whereas intense thunderstroms can attenuate by more than 30 dB km^{-1} at 97 GHz, for example; in other words, only 0.1 per cent of the signal remains after a distance of one kilometre. Fortunately, such events are very confined.

Snow and fog

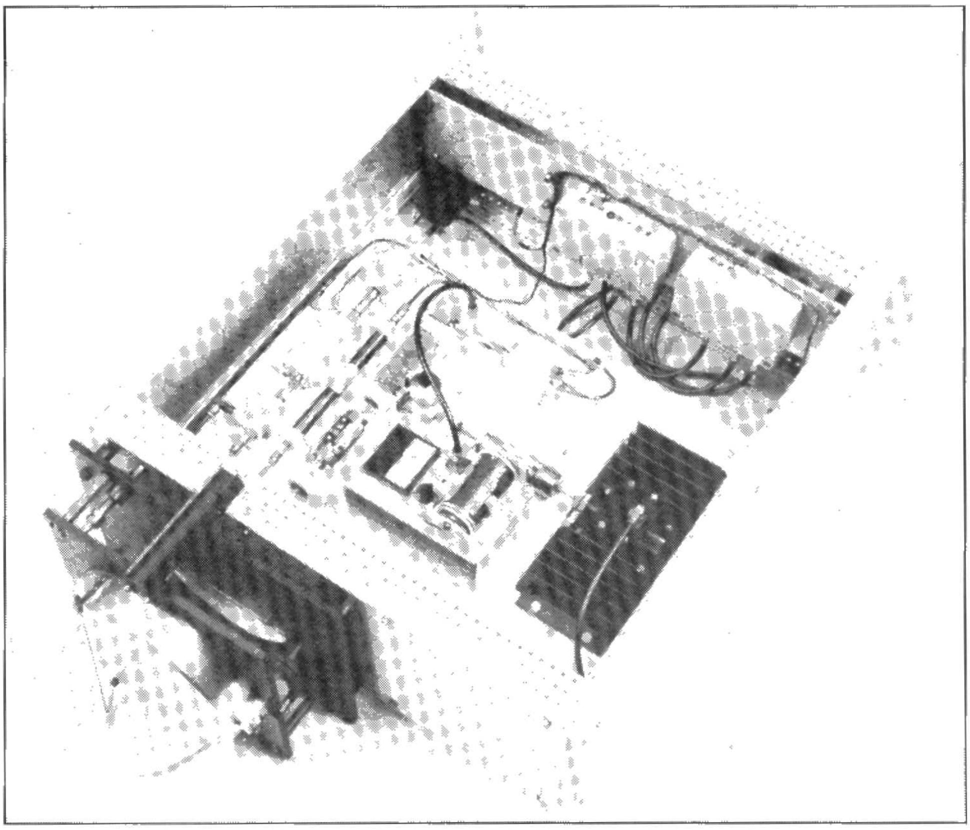
Of great interest is the effect that snow storms have on millimetre communications. There is shortage of such data and the few results available show wide variations. Snow is generally difficult to characterize quantitatively with regard to shape, size and wetness of the flakes. These characteristics vary widely, and when snow is carried by the wind it becomes difficult even to measure effective deposit rates. However, we have developed a rapid response snow gauge which is producing very encouraging results. The effects of wind are kept as low as possible by surrounding the gauge with a fence, which reduces wind speeds close to the gauge and so improves the efficiency of capture. Using this technique, we find good correlations between attenuation and snowfall deposit rates. Results so far indicate that when snow is very dry the attenuations are low, compared with rain, for the same amount of liquid water deposited; but for wet snow, attenuations can be considerably higher. The attenuation clearly depends not only on the amount of liquid water falling, but also on the degree of wetness of the snow flakes. Considerable effort is being devoted to trying to characterize this in terms of other meteorological parameters such as air temperature, so that empirical relationships can be developed to help the prediction of attenuation.

Fogs, on the other hand, affect the millimetre links very little; the wavelengths are much greater than the size of the water droplets and the scattering process, which causes the attenuation, is not significant. In general, the attenuations found at millimetre wavelengths are only a few per cent at the 500 m range. At infra-red and optical wavelengths, however, very severe attenuations, of more than 80 dB km^{-1}, often occur in the visible range in fog, representing a visibility of only about 200 m; only one millionth of one per cent of the signal remains at a distance of one kilometre from the transmitter.

Gas flares

The 500 m range can easily accommodate a variety of different measurements or experiments from other interested groups, especially as all the instrumentation and the data collection system are based on a universal interface standard. As an example of this, an interesting and novel investigation was carried out into millimetre-wave propagation through flames, in collaboration with one of the oil companies operating in the North Sea. The problem was what effect gas flares on the drilling platforms might have on the communications systems. A large flame was generated, about three metres wide, three metres high and half a metre deep and the signals were transmitted through it. Little effect was observed at the lowest frequencies, though large attenuations occurred in the visible range. There was, however, a general increase in the level of scintillation of the signals, which might possibly be of concern at the very high frequencies but of little significance at the frequencies at present in use for communications systems.

The other type of analysis of results is aimed at obtaining the kind of statistical information needed for direct application to communications systems design, for example finding out what fade margins should be allowed for given levels of operational reliability. This is necessarily a longterm project, because it is important to find an average over extremes of the prevailing meteorology and it can be done reliably only over a number of years. Statistical data now being accumulated include such information as the percentages of time that various levels of attenuation are exceeded, from which fade margins can be directly derived; probability distributions of the duration of fades to yield information on the length of data 'dropouts'; the times between fades, which tell us how often deep fades are likely to occur; and the rate of change of fading, which indicates how rapidly signals are likely to change, which is particularly important in digital radio communications systems. The propagation statistics are complemented by similar statistics of meteorological parameters, especially of rainfall rates. Direct comparison of these two sets of simultaneously obtained data then enables propagation conditions to be predicted simply from rainfall data, which is relatively easy and inexpensive to obtain and is measured routinely by weather bureaux in most countries of the world.



The 97 GHz receiver with its 15 cm diameter antenna and swan-neck waveguide feed. Its solid-state local oscillator is mounted on a heat sink on the right-hand side. A battery-operated power supply biases the receiver's Schottky-barrier mixer to its most sensitive operating region.

Future work

The information obtained on the 500 m range will be of immense value in providing propagation statistics and in developing propagation models and prediction techniques for planning future communications systems. The data is being collected over a relatively short distance, chosen deliberately to ensure that the meteorological conditions would be nearly constant over the range. In general, however, practical communications links operating at millimetre wavelengths will have much greater path lengths, perhaps up to several tens of kilometres or more, depending on the frequency.

It is generally found that precipitation, the dominant source of fading in the millimetre region, is characteristically not homogeneous or uniformly distributed horizontally. Widespread (statiform) rain is found to contain imbedded convective cells with higher rainfall rates than the surrounding stratiform regions. Such cells tend, on average, to be about 12 km apart and from two the three kilometres in diameter. As a result, it is not practicable simply to scale the data obtained on the 500 m range to path lengths of more than about two kilometres.

To obtain data over the longer paths which would be used in operational millimetre-wavelength communications systems, an additional link is being developed to operate in conjunction with the 500 m range over a path of about seven kilometres. This will provide data on path-length scaling, in which the 500 m data are applied to longer, more practical link lengths; at the same time it will produce a data base for validating practical prediction techniques. The link will operate at frequencies of 55 GHz, near the peak of the oxygen absorption band, and 95 GHz, in an atmospheric 'window'. These represent two regions of the radio spectrum in which there is considerable interest, for reasons already mentioned, to do with their application to specific types of future communications systems.

These two sets of multi-frequency transmission links, operated simultaneously, will enable us to build up one of the most comprehensive propagation data base for future millimetre-wave terrestrial communications systems design. The detailed and extensive programme of data analysis now going on and being proposed will yield essential information for expanding terrestrial radio communications into the millimetre-wavelength regions of the radio spectrum for the foreseeable future.

NEW LITERATURE

Antennas Volume 2: Applications

by S. Drabowitch & C. Ancona
ISBN 0 946536 17 1
320 pages — 234×156 mm
Price £35.00 (hardback)

This book is the second of a two-volume work intended to provide practising engineers, as well as students of electronics engineering, with a thorough, concise introduction to the applications of antennas. Volume 1, reviewed in the November 1987 issue of this magazine, deals with the most important principles on which the theory of antennas is based.

In the second volume, the authors examine the applications of these principles. Beginning with large antennas, they look at focusing systems and go on to consider the antennas a signal-processing component, providing a novel insight into how the antenna may be treated as a spatial filter.

The second section of the book examines small antennas and plasma-embedded antennas. The quasi-static approximation for low-frequency antennas is presented and followed by a look at dipoles and slots, and frequency-independent antennas.

The final section deals with antennas in linear plasmas, which is of particular importance in the study of antennas on spacecraft and breakdown phenomena.

S. Drabowitch is a consultant at Thomson-CSF, Professor at l'Ecole Superieure d'Electricite, and a senior member of the IEEE. The late C. Ancona was Director of Studies at the Société Technique d'Application et Recherche Electronique, Paris, and Professor at l'Ecole Superieure d'Electricite.

Like the first volume, the present one has been translated excellently by Meg Sanders.

I thought in November that this work could well become a standard work on antennas. Now I have been able to sample the second volume, I am sure of it.

North Oxford Academic Publishers Ltd
120 Pentonville Road
LONDON N1 9JN

Electronic Circuits Handbook

by Michael Tooley
ISBN 0 434919 68 3
277 pages — 246×187 mm
Price £14.95 (soft cover)

The title of this book might well have been *Electronic Circuit Design Handbook*, for that is what it is. A thoroughly practical work that provides the reader with a useful collection of working circuits, together with the necessary supporting information. All circuits can readily be modified or extended by readers to meet their own individual needs.

Related circuits have been grouped together and cross-referenced in the text and index so that readers are aware of which circuits can be readily connected together to form more complex circuits.

Apart from circuit design, the book also contains chapters on tools and test equipment required for the design and construction of electronic circuits and a chapter on the actual construction of a circuit from a 'paper design'. This latter chapter deals with matrix boards, printed circuit boards, soldering techniques, and fault finding. The final chapter is a real gem: it contains ten test equipment projects from a DC power supply through a transistor tester to a pulse generator.

The book gives both the American and British/IEC standards for logic gates, although Mr. Tooley quite rightly points out that (as yet) the American MIL/ANSI standard is preferred by many equipment manufacturers.

Some minor criticisms mainly concern terminology, such as the use of 'duty cycle' and 'fall time', for which the more correct terms are 'duty factor' and 'decay time'. These should, however, only affect students, who will be put on the right track by their lecturers anyway.

Altogether a welcome book for the practising engineer, technician, student, and enthusiast alike.

Heinemann Professional Publishing Ltd
22 Bedford Square
LONDON WC1B 3HH

BASIC & LOGO in Parallel

by S.J. Wainwright
ISBN 0 85934 171 2
152 pages — 178×110 mm
Price £2.95 (paper back)

LOGO and BASIC are two quite different types of computer language. Both were originally developed to enable beginners to make rapid progress in the use of computers.

BASIC is an all-purpose language that is in the same family as FORTRAN, ALGOL, PASCAL, and C.

LOGO is a language in the same family as LISP, and with a philosophy of program development akin to that of FORTH.

It is a common misconception that LOGO is just a Turtle Graphics language. In fact, LOGO has powerful arithmetic and list-processing capabilities, and is one of the languages involved in artificial intelligence aspects of computing. Nevertheless, LOGO's simple but powerful graphics capabilities have given it a place in educational computing as it may help people to experiment and learn by a process of discovery.

This book takes BASIC and LOGO together, and examines how things are done in each of them.

A powerful LOGO-Graphics interpreter written in BBC BASIC is presented at the end of the book. This will enable the reader to explore Turtle Graphics aspects of LOGO before investing in a full LOGO interpreter.

More Advanced Power Supply Projects

by R.A. Penfold
ISBN 0 85934 166 6
92 pages — 178×110 mm
Price £2.95 (paperback)

This book is the companion volume to *Power Supply Projects* by the same author, and should be of interest to anyone who has a reasonable knowledge of power supply basics and would like to learn about recent developments and more advanced designs.

The practical and theoretical aspects of the cricuits are covered in some detail, and the reader is not assumed to have a profound knowledge of electronic circuit design. However, it is recommended that anyone who is not familiar with the fundamentals of power supply design and operation should consult a copy of the companion volume.

Topics included in the present book include switched mode power supplies, precision regulators, dual tracking regulators and computer-controlled supplies.

The book should satisfy the vast majority of power supply design needs not covered in the earlier work.

The two above books are published by

Bernard Babani (publishing) Ltd
The Grampians
Shepherds Bush Road
LONDON W6 7NF

Radiowave Propagation

by Lucien Boithias
ISBN 0 946536 06 6
330 pages — 234×156 mm
Price £35.00 (hardback)

Since the beginning of the twentieth century, dramatic progress has been made in the area of radiowave propagation: the first radiotelegraphic link; the discovery of the ionosphere; and the development of intercontinental telecommunications, radio relay links and satellite communications.

Aimed primarily at practising electrical and electronic engineers, the book presents a comprehensive, structured study of the propagation phenomena occurring between a transmitting and a reception antenna, with one or both of them located on earth.

Using numerous graphs, figures, and

charts, the first part of the book deals with line-of-sight propagation, beginning with considerations of propagation in free space and the fundamental physical phenomena involved: reflection, refraction, diffraction, and scattering. The effects of the ground and the troposphere on propagation are examined together with a review of known anomalies in line-of-sight propagation.
The second part of the book deals with the three major mechanisms affecting non-line-of-sight propagation: knife-edge diffraction, tropospheric scatter, and reflection by the ionosphere, and goes on to consider phenomena associated with noise, particularly over great distances, and to distortions of all kinds affecting radio communication.
Lucien Boithias, a scientist of international repute, is Chief Telecommunications Engineer at the Centre National d'Etudes des Telecommunications (CNET).
Its clear and accessible overview make *Radiowave Propagation* an essential reference work for all those interested in understanding and applying propagation phenomena.

North Oxford Academic Publishers Ltd
120 Pentonville Road
LONDON N1 9JN

BRITISH STANDARDS

BS4061:Part 1:1987
BS4061:Part 2:1987

Both these new standards deal with the *Dimensions of pot-cores made of magnetic oxides and associated parts*, but Part 1 deals with the dimensions in a general manner, while Part 2 deals specifically with pot-cores of British origin.

BS6840:Part 14:1987

Part 14 of the *Sound system equipment* standard is a guide for circular and elliptical loudspeakers; outer frame diameters and mounting dimensions. It excludes cone dimensions of loudspeakers and depth of loudspeakers.

British Standards may be ordered from

The Sales Department
BSI
Linford Wood
MILTON KEYNES MK14 6LE

Readers should also note that each county in the UK has at least one or two large Public Libraries where complete sets of British Standards are kept for general consultation.

PEOPLE

Gary Clark, formerly Software Manager of Camberley-based Base Ten System Limited, has taken up the newly formed position of Business Manager of the company's Telecommunications Products Group.

Ian Summerfield, left, newly appointed by Cirkit as product manager, power supplies and ferrite products, is seen here discussing the Bulgin power supply range with Tim Roe, Bulgin Power Conversion Division's marketing manager.

Roger Lucas, 16 (second from left) and Paul Dagley-Morris, 16 (third from left), both members of Cheltenham College, gained third place in the 1987 Young Engineers for Britain competition, sponsored by the National Engineering Council, for their animal trauma meter (intended for measuring shock in animals). They are seen here with Dr. C.B. Jennings (extreme left), Head of Mechanical Engineering at South Bank Polytechnic, who travelled to Cheltenham to present the awards on behalf of the Council, and Alan Miers (extreme right), Head of Electronics at Cheltenham College, who accepted a cheque for £200 for the College as part of the award.

Louise England, 22, has joined West Hyde Developments, the Aylesbury-based enclosures manufacturer, as Marketing and Public Relations Co-ordinator.

Ken Manser has joined Base Ten Systems Limited as Sales Manager of their Telecommunications Products Group at Camberley.

John Sturmey has joined Roxburgh Electronics as Product Manager for switches. He was previously responsible for international sales at Arrow Hart, covering the North European, Asian, and African markets.

Mietec, the European ASIC manufacturer, has appointed Keith Pruden, 28, as UK Sales Manager with responsibilities for UK sales and customer support.

John Spring has been appointed Product Manager for Passive Components with House of Power, the Orpington-based electronic components distributor.

COMPUTER-CONTROLLED SLIDE FADER (2)

The slide effects unit introduced last month is completed with a control program and an optional keypad that together control no fewer than sixteen slide faders. Although written for the MSX series of home computers, the BASIC program should not be too difficult to rewrite for running on almost any other micro equipped with enough parallel I/O lines for driving the slide controller board(s).

The preparation of a smoothly running slide presentation on four or more projectors is practically impossible without a design tool that enables the photographer to compile his batches of slides, find attractive combinations as regards colour and intensity, and decide on the order, lamp intensity and the time a particular slide is shown. Once all this has been decided on, revised, and once more verified in a trial run of the show, it is possible to store all the necessary commands in the computer for retrieval and automatic execution at a later stage. To aid and guide the many enthusiastic photographers keen on showing their achievement to a larger audience, we have written a BASIC programme for MSX computers, and developed a special command keypad that connects to the computer's joystick input.

Overview of functions

A short description of the commands supported by the slide controller program is given in the Table below. Clearly, the success of the visual effects draws on the photographic ingenuity of the operator, *in casu*, the programmer who creates the file that contains the commands to be executed sequentially. The artistic aspects of creating a slide presentation are not dealt with in this article: general considerations and useful hints can be found in books and magazines on the subject of photography.

When the program is started, it displays the menu screen (see Fig. 1). The user is prompted to select automatic or manual operation by the flashing text:

[A]UTO
[M]ANUAL

The capital letters in square brackets denote the key to be pressed for the associated function. Typing M makes it possible to use the keyboard for selecting control commands from a menu. The selected function is marked with an asterisk (*). The largest possible array of slide projectors is composed of four blocks of four projectors, each with its own address area in the I/O and Timer Cartridge for MSX micros. This arrangement is equivalent to four I/O cartridges fitted in parallel in a single I/O slot, and enables controlling 16 projectors simultaneously via 4 slide controller boards (keep an eye on the total current consumption). Keys [shift]1...[shift]4 select the block number, and keys 1...4 the individual projector. Provision has been made for the simultaneous selection of multiple projectors, which need not be part of the same block. After selecting the projector(s), the command(s) can be issued. Options are displayed at the top of the menu.

1

```
EFFECTS            FADING RATE     SPECIAL

*[D]issolve        [Q] fast        [Home]
 [S]uperimpose    *[N]ormal        [ ] go
 fade [I]n         [L]ong          [C]lear
 fade [O]ut        e[X]tra long
 [T]winkle
 [F]lash

PROJECTOR IN PROJECTOR BLOCK

[1] first         *[shift][1]  1 -  4
[2] second         [shift][2]  5 -  8
[3] third          [shift][3]  9 - 12
[4] fourth         [shift][4] 13 - 16

SLIDE CHANGE

*[.] forward [def]
 [,] reverse
 [/] no change
 [>] forward direct
 [<] reverse direct
```

Fig. 1. The start-up menu prompts the user to enter functions and control commands for the slide fader unit(s).

To begin with, there is, of course, the slide fade effect. This is obtained with the aid of command ''dissolve''. The lamps in all projectors that illuminate the reflective screen are quenched, and those in the selected projectors are gradually turned on. Function ''superimpose'' is similar to ''dissolve'', but works with half the light intensity. Function ''fade in'' turns the lamp in a particular projector on at a certain speed, without quenching the lamps in the other projectors. ''Fade out'' is the complementary function. The fading rate for the above functions is programmable: fast; normal (5 s), long (15 s) or extra long (30 s).
The ''twinkle'' effect gives a fast, sequential projection of slides in a number of projectors (running-light effect),

SUMMARY OF EFFECTS ON COMPUTER-CONTROLLED SLIDE FADER

Fade types:	
hard; snap; cut; flip	very fast fading (<1 s).
fast to very slow	1...>10 s.
Double projection:	
superimpose	projects two slides simultaneously.
flash	flash-like appearance of a slide onto the projected image.
partial image	a number of masked slides are projected simultaneously.
Twinkling and animation	fast sequential projection of slides.
Fade in	projector lamp intensity is gradually increased.
Fade out	projector lamp intensity is gradually reduced.
Clear	all slide carriages are returned to position 1.
Slide carriage control	forward, reverse.

while "flash" gives a brief, single, projection of one or more slides.

Five options are available for slide carriage control. The first, "forward", is the default function that results in automatic feed-forward of the slide carriage following a fade-out command, i.e., it can only operate in conjunction with effects "dissolve", "superimpose", and "fade out". Function "reverse" is similar to "forward", except, of course, for the direction of travel of the slide carriage. Automatic slide changing is disabled with function "no change". Functions "forward direct" and "reverse direct" give instantaneous slide changing. Selected projectors provide a fade out (unless the lamp was already quenched), followed by a slide carriage feed in the relevant direction.

As to the special functions shown in the menu: "go" (space bar or return key) runs the selected function or effect. The selected function is not carried out, however, before the relevant projectors have completed previously received commands. Function "home" has two options. Pressing the home key causes the selected projector(s) to revert to the first slide, but not before the projector(s) lamp(s) is/are quenched. Pressing the [shift] and [home] key simultaneously causes all projector lamps to be quenched, all slide carriages to be set to the first position, and all projectors to be deselected. Function "clear" ignores keyed-in commands, and restores the previously selected function.

Command strings

An example may help at this stage to illustrate the programming procedure. The following command string is keyed in:

[shift]4IQ12 F3 4 ON1234[return]

Note that the 3 spaces are significant, as they stand for "go". [shift]4 selects projector block 4 (projector numbers 13...16 incl.). I and Q announce a fast fade-in on projectors 1 and 2 of block 4 (numbers 13 and 14). The space character that follows causes the programmed function to be carried out. F3 selects a flash on projector 3 in block 4 (number 15), and the space brings it into effect. 4[space] causes a flash from projector 16. Note that it was not necessary at this stage to type another F, since the flash function is still in operation. The next command sequence, ON1234[return] results in a fade-out at normal speed, followed by a carriage feed-forward. The fade-out is not effected on projectors 15 and 16, since these had their lamps fully quenched already, but the automatic feed-forward (default) is still effected. Commands and selections are not brought into effect before "go" is selected; editing of command sequences is, therefore, possible. Selection of other projectors is, however, only possible after a "clear" command.

Automatic control

It is, of course, convenient to run the compiled presentation automatically. The control program supports automatic operation with or without tape synchronization.

Projector commands can be put in DATA lines from line 8ØØØ onwards (an example of an automatic presentation is included in the programme listing). The structure of the lines is similar to the previously discussed strings that are entered manually. If available, the disk drive on the computer may be used for storing projector commands on floppy disk. Disk or tape storage is not supported by the control program, however, so that suitable save and load procedures will have to be provided by the programmer.

A number of additional program functions are available during the automatic execution of the slide show. Pressing key "M" reselects manual operation, while "A" reverts to the automatic mode, in which the computer continues processing the data from where it was interrupted. If necessary, slide carriages are returned to the positions they had before the automatic mode was interrupted. Function "W" waits for the space bar to be pressed, or for "M" to select manual operation. This makes a short pause possible for exchanging complete slide carriages. Function "R" (restore) causes the program to start at the first data line, after returning all projectors to the initial settings. Function "E", finally, ends the show. Programmers should note that "E" and "R", contrary to the other functions, must each be put in a separate data line. The home key can not be put in a data line in the form of an ASCII character. This problem has been solved by the use of letters "h" and "H", which represent [home] and [shift]home, respectively. The other functions recognize both capitals and lower case letters.

Synchronization to a tape recording is effected via the trigger input on the joystick interface (hardware), and the wait-for-tape routine (software). The (relay) output of the pulse decoder is connected between trigger input A and GROUND of joystick 1. A simple record/playback system for taperecorders is shown in Fig. 2. The 1 kHz tone generator (Fig. 2a) is activated by pressing S_1. The tone decoder (Fig. 2b) is connected to the AF output of the recorder, and energizes the relay contact when the tone is detected as the tape is being played back.

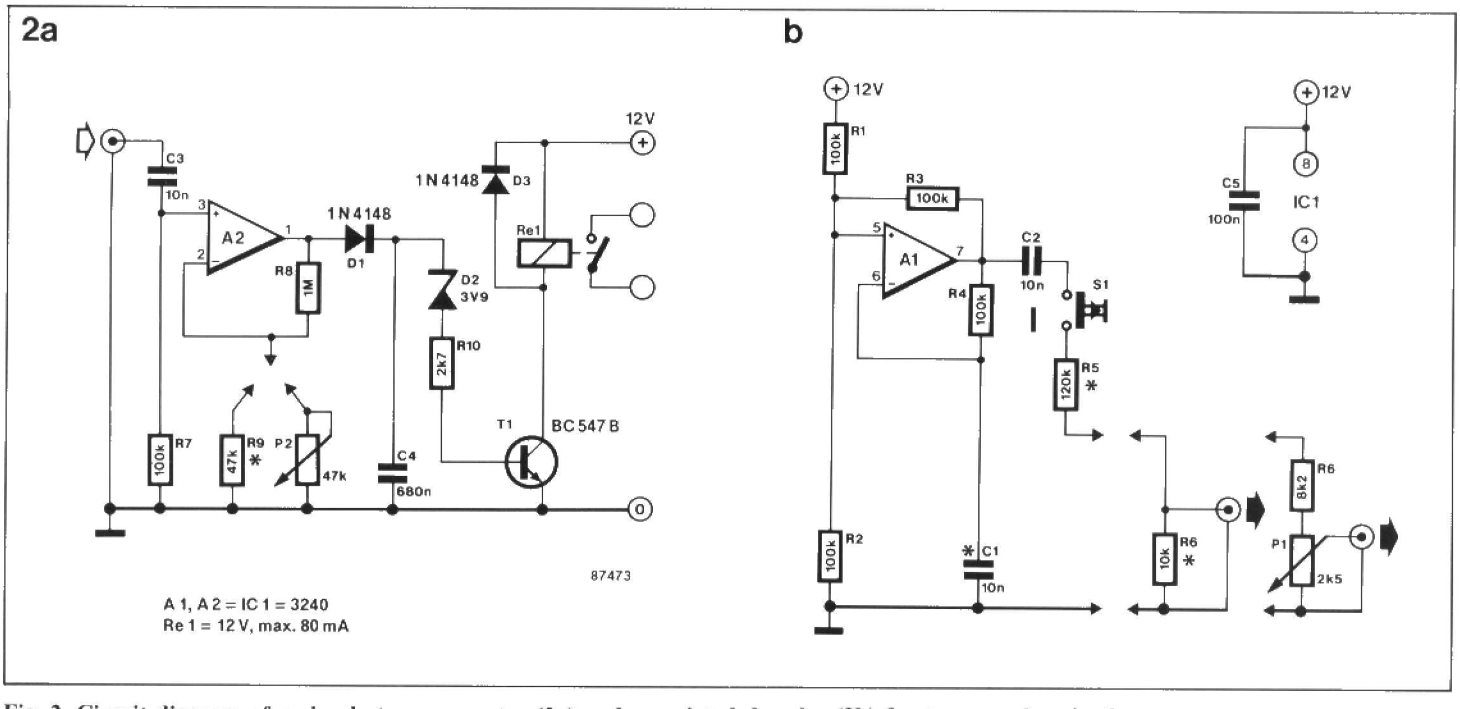


Fig. 2. Circuit diagram of a simple tone generator (2a) and associated decoder (2b) for tape synchronization.

The Record-Playback Amplifier described in [1] is ideal for use in conjunction with the tone generator and decoder. To prevent it being overdriven by the tone generator, it is recommended to use the resistor-potentiometer configuration shown as an option for the circuit of Fig. 2a. Also, C_1 is best increased to 100nF to lower the tone frequency to about 100 Hz. In the tone decoder, P_2 is fitted instead of R_9 to enable accurately setting the optimum sensitivity.
Programming the slide sequence is facilitated by the message ''press button'', displayed following the execution of a command. The user can then arrange for the next synchronization pulse to be recorded on tape.

Program description

The program listing starts with an overview of the variables used (lines 14Ø...53Ø). This should prove helpful for possible extensions at a later stage, and prevents the programmer losing track of declared variables. Many variables are declared as arrays, in which each element belongs to a particular projector. There are also arrays that contain only two elements. These are not declared beforehand, since this is not required in MSX BASIC for arrays of up to 11 elements (0...10 incl.). A number of variables will be discussed below with an aim to clarify the operation of the control program, and to aid programmers of non-MSX computers converting the software for use on their machine.

Variable X is a counter used within the ON INTERVAL routine in lines 55ØØ...569Ø. This variable may not be used for other purposes after the ON INTERVAL initialization, because intervals always return X as 16, irrespective of the previously assigned value. Arrays T1...T6 hold the timing periods that are used during the changing of the slides. T1(I) determines the on-time of the feed-forward relay that controls the carriage in projector I. T2(I) indicates the wait time before the change is complete. T(3)I and T(4)I have similar functions for reverse changing. Variables T(5)I and T(6)I serve as counters during the changing period. Their starting value is copied from T(1)I and T(2)I, or T(3)I and T(4)I. The values in arrays T1...T4 depend on the specifications of the projectors used, and may be defined individually for each projector. In practice, it will be found that a single value for the arrays enables satisfactory operation of all projectors, even if these differ in respect of type and make.
Arrays Bl and B2 indicate activity of any one projector in the system. B(1)I indicates whether or not the lamp intensity for the relevant projector is being changed, while B(2)I signals slide changing activity. The fade rate is set by the values in S(1), S(2), DE(1) and DE(2). S(1) and S(2) indicate the step size used for increasing or reducing the lamp intensity. DE(1) and DE(2) define the number of times the ON INTERVAL routine is skipped before the lamp intensity is re-adjusted. The values assigned to these variables depend on the selected FADING RATE. The (temporary) step size and delay information are recorded separately for each projector with the aid of variables S1(I), D(1)I and D(2)I. Among the most essential lines in the program is number 86Ø. This determines the rate at which the command execution subroutine is called. Statement ON INTERVAL=15 causes the main program that arranges the entering of commands to be interrupted at 15×20=300 ms intervals to write new data to the slide controller board(s). Command input is thus separated from command output, preventing key actions disrupting an effect while this is being executed. The interval rate is set to 300 ms to allow sufficient time for the computer to run the interval routine (line 55ØØ...569Ø). Too short an interval time would cause the interrupt to be generated during the execution of the interval routine, making it impossible for the computer to return to the main program. It was found that 300 ms gives a reasonable time division between the main program and the interval routine. If the interval time is changed, all variables containing period definitions must be changed also (T1..T4, DE1, DE2, S1 and S2).

An optional keypad

The circuit diagram of an external, optional, keypad for entering all program functions is given in Fig. 3. The keypad is connected to the second joystick input, and is essentially an extended ver-

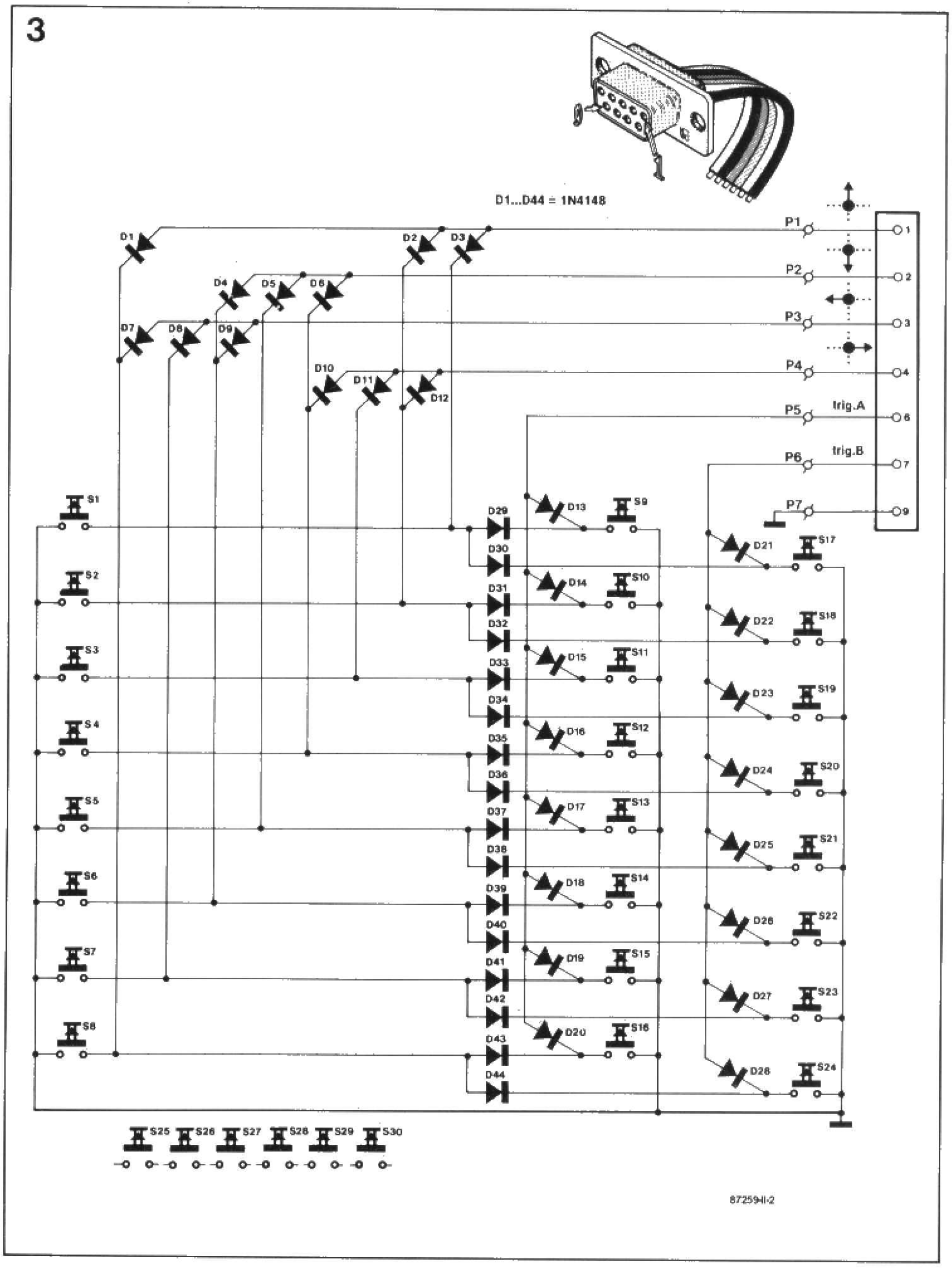


Fig. 3. Circuit diagram of the auxiliary, optional, keypad connected to the joystick input on the computer.

4

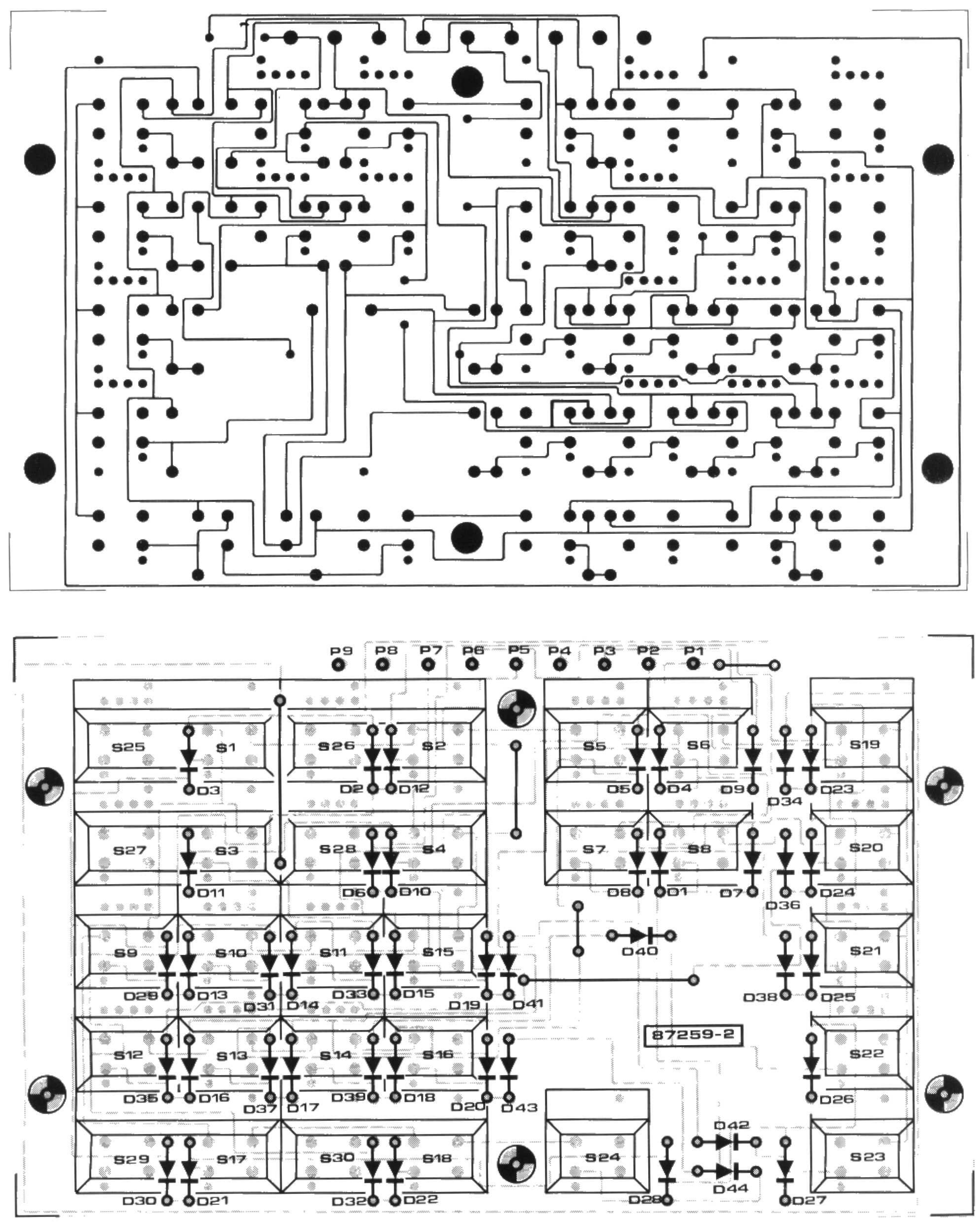


Fig. 4. Layout of the keypad PCB (not available through the Readers Services).

sion of the circuit described in [2]. Figure 4 shows the track layout and component mounting plan. It should be noted that this PCB is **not** available ready-made through the Readers Services. Buttons $S_{25} \ldots S_{30}$ incl. are dummy switches covered by 6 double-size keytops.

The machine-language routine that belongs to this control keypad is linked to the computer-resident keyboard driver (lines 5800...5990). When writing or debugging one's own control routines, it is important to remember that the keyboard routine is loaded only once. This is so arranged because the hook vector that points to the keyboard routine of the computer is moved and replaced by the start address of the keypad routine. Running this procedure twice causes the computer to lose track of the starting address of the resident keyboard driver, so that the slide control program

Parts list
9-way female sub-D connector
$D_1 \ldots D_{44}$ incl. = 1N4148
$S_1 \ldots S_{30}$ incl. = PCB mounted data switch; momentary action. Licon series 61 Alpha Type 61-101xx00 (xx is keycap colour code).
Keycaps: 6 off double, and 18 off single. ITW Switches • Division of ITW Limited • Norway Road • Hilsea Industrial Estate • Portsmouth PO3 5HT. Telephone: (0705) 694971. Telex: 86374.
Note: it is regretted that the PCB for the auxiliary keypad is not available ready-made through the Readers Services.

is apparently not working. Data errors reported during tests invariably require instruction POKE &HF975,ØØ to be run before restarting can take place.

The keypad routine can be tested separately with the aid of line

KEY = STICK(X)−(8*STRIG(X))−(16*STRIG(X+2))

where X is the number of the joystick port.
Alternatively, use

1 DEFINT A: A=USRØ(Ø): IF A<>Ø THEN PRINT A: GOTO 1 ELSE 1

Instruction A=USRØ(Ø) fetches the number of the actuated key. Its effect is similar to statement A$=INKEY$. The routine has a buffer with a holding capacity of 128 key actions. The buffer is cleared by pressing keys [shift] and [clear] sequentially, while just [clear] empties the buffer until the last "go" command. The [shift] key must always be pressed individually to ensure that the keypad routine assigns a different number to the next key pressed. The key numbers returned by the routine correspond to the numbers of the switches (1...23 incl.; 24 is the [shift] key). The number is increased by 24 when the previously pressed key was [shift] (25...47 incl.). The keypad routine returns a nought to indicate that no key was pressed when it was called. *R*

References:

(1) Record-playback amplifier. *Elektor Electronics* October 1987, p. 44 ff.
(2) 16-key input for MSX micros. *Elektor Electronics* July/August 1987, Supplement p. 17.

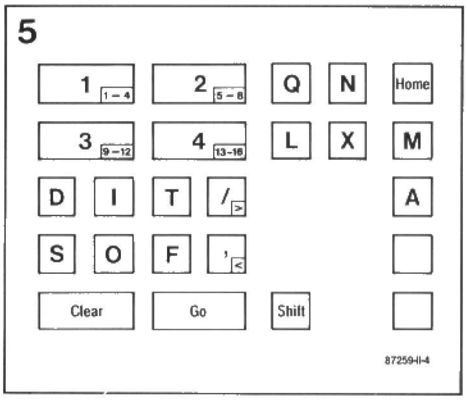


Fig. 5. Location and lettering of the keys on the auxiliary keypad.

The listing of the BASIC control program is available free of charge by sending a self-addressed, stamped envelope to our Brentford office (overseas readers: please include 2 IRCs).

ELECTRONICS NEWS

Colour television monitor

Vistek's high-standard grade 2 colour television monitor has been designed for general-purpose applications in studio and similar environments where grade 1 performance is not required. The GM2716's all-round performance and wide range of facilities are said to make it ideal for most colour monitoring requirements.
Vistek Electronics Ltd • Unit C • Wessex Road • BOURNE END • Buckinghamshire SL8 5DT.

Optical fibre cleave tool

A new tool to facilitate the cleaving of optical fibres is being produced under licence from British Telecom PLC. It consistently produces highly accurate squarely cleaved faces and is rugged enough for use by technicians at the roadside during optical-fibre installation.
The tool is self-calibrating with a wide range of fibre types: 50/125; 62.5/125; 85/125; and 100/140 multinode all-silica, and 5/125 and 8/125 monomode fibres. Further information from **K.W. Kirk & Sons • The Winship Industrial Estate • Milton • CAMBRIDGE CB4 4BD.**

Electronic fingerprint recognition

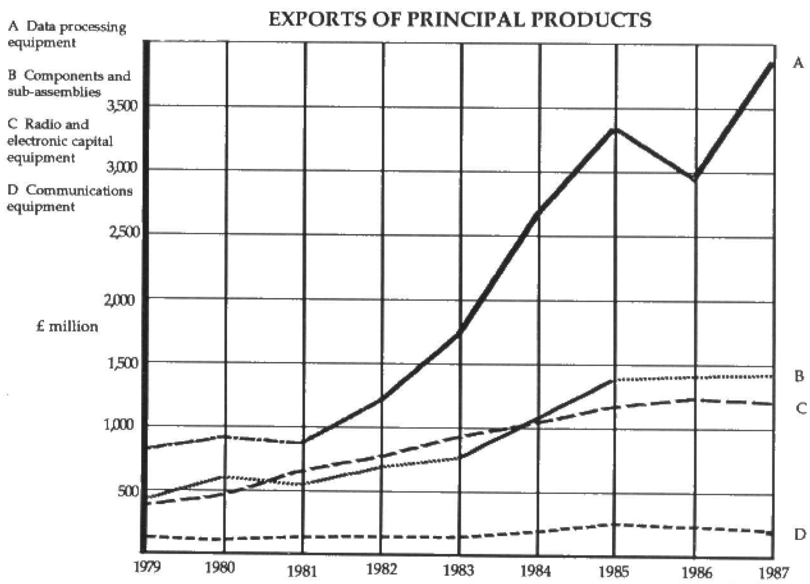
An electronic fingerprint recognition system developed by scientists at Edinburgh University's electrical engineering department has received £500,000 backing to build a full-scale demonstrator and carry out field trials.
The system was invented by the department's Professor Pete Denyer and a prototype has already been built and tested. Potential applications for the device, which electronically matches a presented fingerprint against a memory store of "authorized" prints, include door and computer systems security and point of sale machines.
Initial development work was supported by the Quantum Fund, which is backed by the British Linen Bank, the Scottish American Investment Company, and Edinburgh University to provide venture capital for commercially exploitable work at the university.
Quantum will provide further capital to enable the university team to build a full-scale demonstrator of the device. This will then undergo field trials with De La Rue Company, who will have exclusive rights to the technology.

THE ELECTRONICS INDUSTRY

The UK Electronics Industry continues to face a strong international challenge at home and abroad. The EEA News Bulletin tells how the major UK electronics companies are achieving success in UK and Export markets by selling equipment, systems and software using the most advanced technology.

EXPORTS

The UK Electronics Industry exports half its production of equipment, systems and software. Total exports have trebled in value between 1980 and 1987, led by exports of data processing equipment, which in 1987 resumed their upward trend. All other sectors also increased their exports, with radio and electronic capital equipment maintaining a positive balance of trade in civil and defence goods. The relatively low level of export of communications products reflects the closed nature of this market; Government and EEC moves to open international competition in telecommunications are to be encouraged.

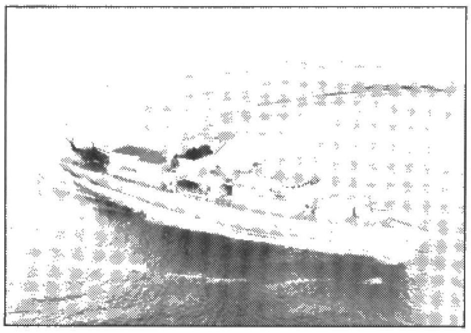


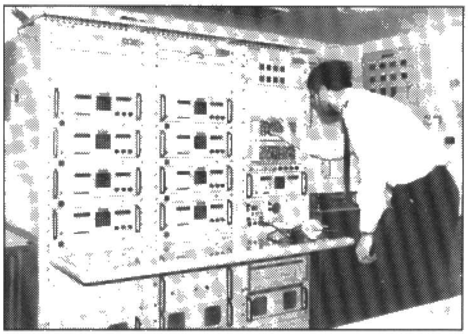
Source: The Electronic Engineering Association

CEPT European standards institute

In the wake of the EEC proposal for the development of a 'real' common market for telecommunications equipment and services (as first reported in our September 1987 issue), the Directors General, Telecommunications, of the Conference Europeenne des Administrations des Postes et des Telecommunications—CEPT—have decided to establish an autonomous European Telecommunications Standards Institute.

This decision marks a major step forward in the production of European Telecommunications standards.





Rediffusion Radio Systems' LF/MF/HF communications system console which the company will fit in seven Type 23 frigates and two training outfits of the Royal Navy.

Incomtel brochure

International suppliers of telecommunications and broadcasting services, Incomtel, have increased turnover by 50% through projects in thirty countries.

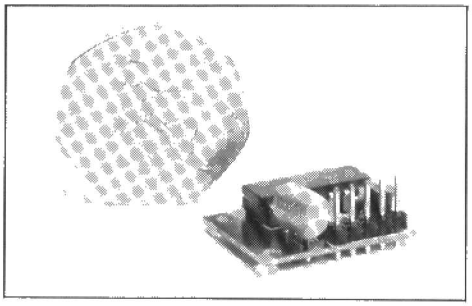
To mark this, the company has published a new brochure which outlines the full range of facilities now available.

Their services include feasibility studies and project planning to project completion and on-site training of local staff. All design work is undertaken in the UK, but Incomtel's own engineers and technicians always take up residence in the country concerned to supervise projects.

INCOMTEL Ltd • 225 Goldhawk Road • LONDON W12 8SB • Telephone 01-743 5511.

New CTCSS panel

A new CTCSS encode only panel, Type CDS37E, has been announced by Communication Development Specialist. The



panel complements the VE CTCSS encode panel and provides a programmable encode only facility for most two-way radio applications.

CDS Limited • P.O. Box 83 • BASINGSTOKE RG25 2PX • Telephone (0256) 83528.

New RF amplifier chip

National Semiconductor has introduced a low-noise RF amplifier for use over the frequency range 500 kHz to 1 GHz. The device has a power gain of 14 dB at 500 MHz.

The LH4200 is a hybrid IC with a gallium-arsenide front end for high speed, and bipolar 2nd and 3rd stages for high-power output. Output impedance is 50 ohms.

National Semiconductor Corporation • 301 Harpur Centre • Home Lane • BEDFORD MK40 1TR • Telephone (0234) 47147.

Revised circuit analysis package

Number One Systems' PC circuit analysis package, ANALYSER II, has been thoroughly revised to include analysis of Microwave Striplines and Transmission Lines. This is a very rare facility in low-cost design tools which will make a significant contribution to removing the mystique of HF circuit design. The revised package will be discussed further in our July issue. In the mean time, further information may be obtained from **Number One Systems Ltd • Harding Way • Somersham Road • St. Ives • HUNTINGDON PE17 4WR • Telephone (0480) 61778.**

New PAL coder

The latest addition to Visitek's Varicomb range of high-quality coding and decoding equipment is an entirely new PAL coder that provides a 'clean' luminance signal, free from chroma modulation, but without the timing problems normally associated with comb-filter designs.

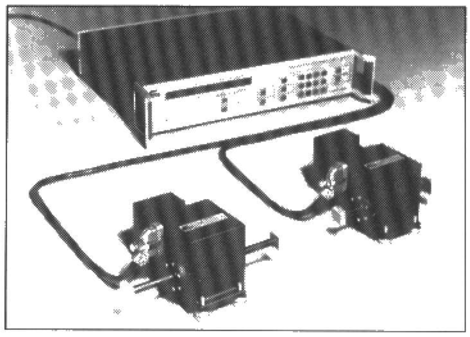
Vistek Electronics Ltd • Unit C • Wessex Road • Bourne End • Bucks SL8 5DT • Telephone (06285) 31221.

Module stores four lines of video

BAL Components are offering a new Microsonics VDM36 series 2H/4H video delay module capable of storing four lines of video.

The VDM36 provides two 128 μs video in/video out delay channels, which can be cascaded to form a 4H delay with a 2H tap, or used independently as 128 μs delays.

BAL Components Ltd • Bermuda Road • NUNEATON CV10 7QF



Control processors for microwave and radar applications have been developed by *Flann Microwave Instruments Ltd • Dunmere Road • Bodmin • Cornwall*. They were designed for remote computer control via the general purpose interface bus—GPIB—or local, manual control via a front panel.

ERA satellite seminar

The rapid growth in satellite communications has led to an increasing need for high data-rate links between spacecraft to enhance the capacity, coverage and connectivity of systems. The implications of adopting such links will be discussed at ERA's forthcoming seminar *Interorbit and Intersatellite Links: Systems and Technology*, which will take place on 29-30 June, 1988, at the Royal Garden Hotel, London. Further information from **ERA Technology Ltd • Cleeve Road • LEATHERHEAD KT22 7SA • Telephone (0372) 374151.**

SUPERCONDUCTIVITY: FURTHER OUTLOOK WARMER

by George Short

London's Science Museum recently acquired a new exhibit. It is not much to look at: a cylinder of black ceramic material. But the small company from the London suburbs which made it is proud to claim that it is the world's first high-temperature superconducting solenoid. It is just one manifestation of the burst of research activity into a new class of superconductive materials.

Superconductivity is the property of certain materials to lose all electrical resistance. The phenomenon was discovered by the Dutch physicist Heike Kammerlingh Onnes, who announced in 1911 that mercury becomes superconductive when cooled to a very low temperature, about four degrees above absolute zero (4 K).

It soon emerged that a number of metals become superconductive when cold enough. In every case the temperature required was only a little above absolute zero, attainable in practice only by immersing a specimen in liquid helium, which boils at 4.2 K at atmospheric pressure.

Having to reach such a low temperature was inconvenient but did not preclude what seemed at first to be an ideal application of the discovery, making electrical motors and generators of high power and efficiency. A great deal of the energy wasted in electromagnetic machines is in heat generated through the resistance of their windings by the flow of current. Removing the resistance by making the windings out of superconductive wires eliminates the loss.

Unfortunately, this hope was dashed by the discovery that superconductivity is destroyed when the wire is immersed in a strong magnetic field. Because motors and generators need strong fields to operate properly, the hoped-for improvement seemed unattainable.

Further research

Nevertheless, superconductivity was a fascinating and unexpected effect. For that reason alone it became an important subject for physical research, and more was discovered.

What makes a superconductor lose its resistance? At first it seemed likely that at the very low temperatures involved the atomic structure of the material arranged itself in a perfectly ordered form. Electrons could then, it was argued, move through the empty space between the atomic nuclei without colliding with anything and losing energy. But the explanation is far more complex.

One interesting aspect is that the electrons which mediate superconductivity appear in what are known as Cooper pairs, with opposite spins. Subtle quantum effects are involved, too.

Loss of electrical resistance is only one of several changes that take place when a superconductor is cooled below the critical temperature at which resistance disappears. There are striking magnetic effects: the permeability of the material drops to zero and magnetic flux in the material disappears; the thermal conductivity increases sharply.

The phenomenon of electron tunnelling, whereby electrons are able to penetrate barriers which classical physics once deemed impassable, is particularly important. Professor Brian Josephson at Cambridge University, who gained a Nobel Prize for his work, predicted and demonstrated that when two superconductors are separated by a very thin insulating layer electrons are able to pass through the insulation even when there is no electromotive force to drive them. If a driving voltage is applied, oscillations are produced at a frequency which depends only on the voltage and two well-known physical constants, Planck's constant and the charge on an electron. One implication is that if the frequency is measured the applied voltage can be calculated. This means that a Josephson junction, as it is now known, could provide for the first time an absolute measure of the volt.

Niobium tin

About half a century after superconductivity was discovered another finding suddenly renewed hopes of putting the effect to practical use. This was the possibility of making metallic alloys that would stay superconductive in very high magnetic fields. Alloys of niobium and tin are now used in powerful electromagnets.

An electromagnet of normal construction has the unenviable quality of manifesting zero efficiency, for all the energy in the driving current is dissipated in the resistance of the coil wire. If this resistance were reduced to zero by using superconductive wire, the ends of the winding could be connected together, leaving the energising current to circulate for ever without external help.

The idea is so attractive from the engineering point of view that it is worth going to the expense of installing liquid helium refrigeration to keep the coil cold. The energy saved by abolishing coil resistance more than pays for the cost of refrigeration. At any rate, that is so in the applications for which superconducting solenoids are used. These include field coils for nuclear magnetic resonance body scanners, chemical microwave spectrometers and large particle accelerators. The wires used for the windings are composite: the superconductive alloy parts are bonded to copper conductors. If, as can happen, a small part of the superconductor is overloaded and reverts to ordinary conductivity the copper acts as a temporary low-resistance bypass until it cools down. Suitable alloys are being made in the UK by IMI.

Superconducting coils have been proposed for use in hovertrains. The idea is to use superconductive electromagnets to suspend the train in the air only a short distance below an overhead track. In this way friction could be minimised and the train would glide along smoothly at high speed.

A less futuristic use of magnetic levitation is in a superconductive bearing. One consequence of the magnetic properties of a superconductor (or, rather, its antimagnetic properties) is that a magnet brought near to a piece of superconductor experiences a repulsive force. Given a suitably shaped superconductor, this repulsion can keep the magnet floating in the air. So, if the magnet is an axle, it can be rotated virtually without friction. On a small scale such a low-friction

bearing could be very useful in gyroscopes for navigational instruments, where frictional drag is a source of error. On a larger scale, a combination of superconductive coils and floating axles would be useful in electric motors and generators.

Electronic applications

It is hoped that with the arrival of 'high-temperature' superconductors many of the possible low-power applications worked out with liquid-helium-cooled devices will become much more practicable.

The new superconductors work at temperatures above the boiling point of liquid nitrogen (77 K or −196 °C). Liquid nitrogen is relatively cheap and safe. One litre of liquid helium costs around four US dollars, is expensive to store and tricky to handle. Liquid nitrogen in Britain is cheaper than beer and easy to handle. At a recent demonstration at the Royal Society in London, researchers on superconductivity from Birmingham University, in the English midlands, stored it in ordinary vacuum flasks of the kind used at picnics and poured it out for use into throwaway plastic cups.

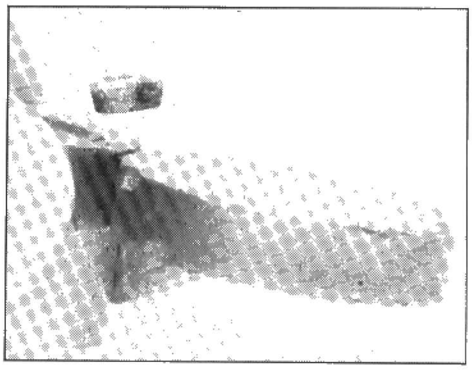
One envisaged application is the cryogenic computer. The technology has already been worked out, notably by IBM, but shelved because of the liquid helium problem. The computer makes use of the fact that superconductivity can be destroyed by a magnetic field. This, a nuisance in power applications, is a blessing for computing. It enables the resistance of a circuit to be switched from nothing to something small but finite, which is the basis of gate circuit. If gates can be made, computing circuits are feasible. The absence of resistance in the superconducting state makes for high speed operation, and speed is a prerequisite for improving conventional computers in which operations are carried out in sequence and the duration of a sequence determines the speed of working.

Extremely sensitive

Resistance in communications engineering brings with it another penalty: noise. Any resistance in an amplifier generates noise, which sets a lower limit to the amplitude of signal which can be detected. Below that limit the resistance noise drowns the signal. For satellite and deep space communications it would be attractive to reduce amplifier noise by incorporating superconductors into the early stages of receivers. Some liquid-helium-cooled devices are in use now; liquid-nitrogen-cooled amplifiers should enable the cost to be reduced and the field of application widened.

One amplifying device already achieved in liquid-nitrogen 'high-temperature' form, at Strathclyde University, Glasgow, is the superconductive quantum interference device, or SQUID. A SQUID is essentially an extremely sensitive detector of changes in magnetic field strength. Its uses range from military to medical. A SQUID can, for instance, detect submarines by monitoring the changes they produce in the Earth's magnetic field in their vicinity. It can monitor blood flow (blood is magnetic) when placed near a blood vessel.

In radio, superconductors could be used to reduce the size of aerials, which are usually made in dimensions that bear a simple relation to the wavelength. The ubiquitous half-wave dipole is an example.



A piece of yttrium barium copper oxide superconductor floats above a strong permanent magnet.

Attempts to reduce the size to a very small fraction of a wavelength are vitiated by a sharp reduction in the aerial's ability to radiate signals. This ability is described in engineering terms by saying that an aerial has a certain radiation resistance. A resistance absorbs energy and the radiation resistance of an aerial is really a fictitious quantity which describes the aerial's ability to launch energy into the space around it. Aerials much shorter than a wavelength have very low radiation resistance. A short vertical wire aerial, for example, behaves like a resistance of a tiny fraction of an ohm in series with a very high capacitive reactance. In theory it should be possible to tune out the reactance and allow energy to flow freely to the resistance (that is, to radiate). In practice, the losses of the inductance coil needed to tune out the aerial capacitance are so great that virtually all the energy is lost in the coil.

If the coil could be made superconductive this waste could be avoided. A short aerial could then, in theory, be as efficient a radiator as a long one. And, because a good transmitting aerial is a good receiving aerial too, a short superconductive receiving aerial should also be efficient. One form of aerial which seems to hold great promise for fabrication in superconductive form is the loop aerial. It is in effect a form of electromagnet coil and in its normal form is inefficient.

The ceramic nature of the new high-temperature superconductors poses problems in applying them. The materials themselves are quite easy to make. The current most popular one, yttrium barium copper oxide ($YBa_2Cu_3O_7$) has been made in school laboratories in the USA and Britain. It is, however, brittle. This is the reverse of what is needed, which is a ductile, easily formed material, capable of being drawn into wires, pressed into sheets and foils and so on. Fortunately, some of the computing-type applications call for very thin layers deposited on insulating substrates. Several standard methods for making these are available, including simple vapour deposition in vacuum and deposition from an ionised gas. Even printing, using inks made of the requisite materials, shows promise. If the material in powder form can be made to superconduct, it should be possible to form 'wire' by first packing the powder into a metal tube and then reducing the tube diameter by a wiredrawing technique, squeezing down the powder inside in the process. It may well be that success in applying the new materials will depend more on the development of suitable fabrication techniques than in a deep understanding of how they work at the crystal structure level.

Even higher temperatures?

Why stop at liquid nitrogen temperatures? Why not make room-temperature superconductors and avoid the cooling problem altogether?

A few years ago this seemed impossible. Recently, there have been reports and rumours of apparent superconductivity, if not at room temperatures at least at temperatures far above that of liquid nitrogen. So far the results have proved not to be reproducible. This very-high-temperature superconductivity appears to have been produced by some fortunate accident during the manufacture of the new ceramic superconductors. And it has been transient, disappearing when the material is heated and cooled a number of times. This suggests that it may be a new form of superconductivity which is a function of the internal structure of the bulk material and appears only when the heat treatment (sintering of metallic oxides at about 950 °C) used in its manufacture chances to be right. Once the process is understood it may be possible to reproduce it to order. Yet another class of superconductors may be on the way.

THE EFFICIENT ALTERNATIVE TO LARGE POWER STATIONS

by Dave Andrews

Decentralizing electricity generation, but maintaining a grid system with a much larger number of small power stations, is an idea gaining favour with many engineers. Installations in industrial premises can generate enough power for local needs and in off-peak periods feed power into the grid system for other users. Moreover, such stations are already developed and on the market, and their efficiency ratings are impressive.

In most of the industrialized world, generating power on a large scale has followed a trend away from large numbers of very small power stations to small numbers of very large ones. The reasons have been that coal-fired steam cycle stations showed impressive economies of scale, for large power stations could be made more efficient: developments in high-voltage transmission meant that the large stations could be built out in the country, where land was cheap and pollution was not so noticeable.

In the UK, generating sets work at up to well over half a thousand megawatts, compared with a few hundred kilowatts when large-scale generation of electricity began. This established model has been seen as the economical path for developing countries too: diesel generators serving remote villages are giving way to large, central power stations, and distribution by overhead high-voltage lines.

However, this model may have been turned on its head by the development of a new kind of mini power station. Even smaller than the first power stations, it is cheaper, nearly three times as efficient and less polluting than they were. Such a station is so small that it can be tucked inside existing buildings. Large numbers of them could be installed in an industrialized or a developing country, generating power at low voltage and feeding any surplus into the public supply, to be sent to other load centres. This arrangement would save heavy investment in central power generation and high-voltage transmission lines. There are now about 200 of these small stations already installed in the UK.

Power output

A mini power station usually consists of an industrial gas or diesel engine driving a generator, just as in a conventional station but only the fraction of the size. A typical output is about 40 kWe (kilowatts, electrical) compared with a typical conventional station's 2000 MWe (megawatts, electrical). Mini stations now range in output from 18 kWe to 2.5 MWe. Under development are units for 3 kWe and 8 kWe. One kilowatt of output is enough to run a single bar of an electric fire.

A typical twin-set mini power station.

The mini station is fitted with equipment that enables it to be directly connected to a public supply cable and operate in parallel with it. Its output is used within the building or, if it is producing a surplus, the extra energy is sold to be public supplier. Modern electronics techniques enable systems to be produced that can start up and connect themselves to the alternating-current mains supply entirely automatically, and to stay synchronized with the mains frequency and phase. In small stations up to about 90 kWe this is achieved by using an asynchronous generator, which is used first as a motor to start the engine, and then as the generator; this does away with the need for starter batteries. The asynchronous generator has the advantage that it is always synchronized with the frequency of the supply to which it is connected, so no synchronization procedure is needed. In larger systems, where the inrush of starting from the mains would be too high, battery start and synchronous motors are used. With a synchronous generator, automatic synchronizers are used to bring the generator into correct phase and synchronization with the mains before the mains contactor closes. Automatic devices monitor and control all aspects of the systems's performance, and either indicate alarms or shut the units down if there is any mechanical or electrical defect.

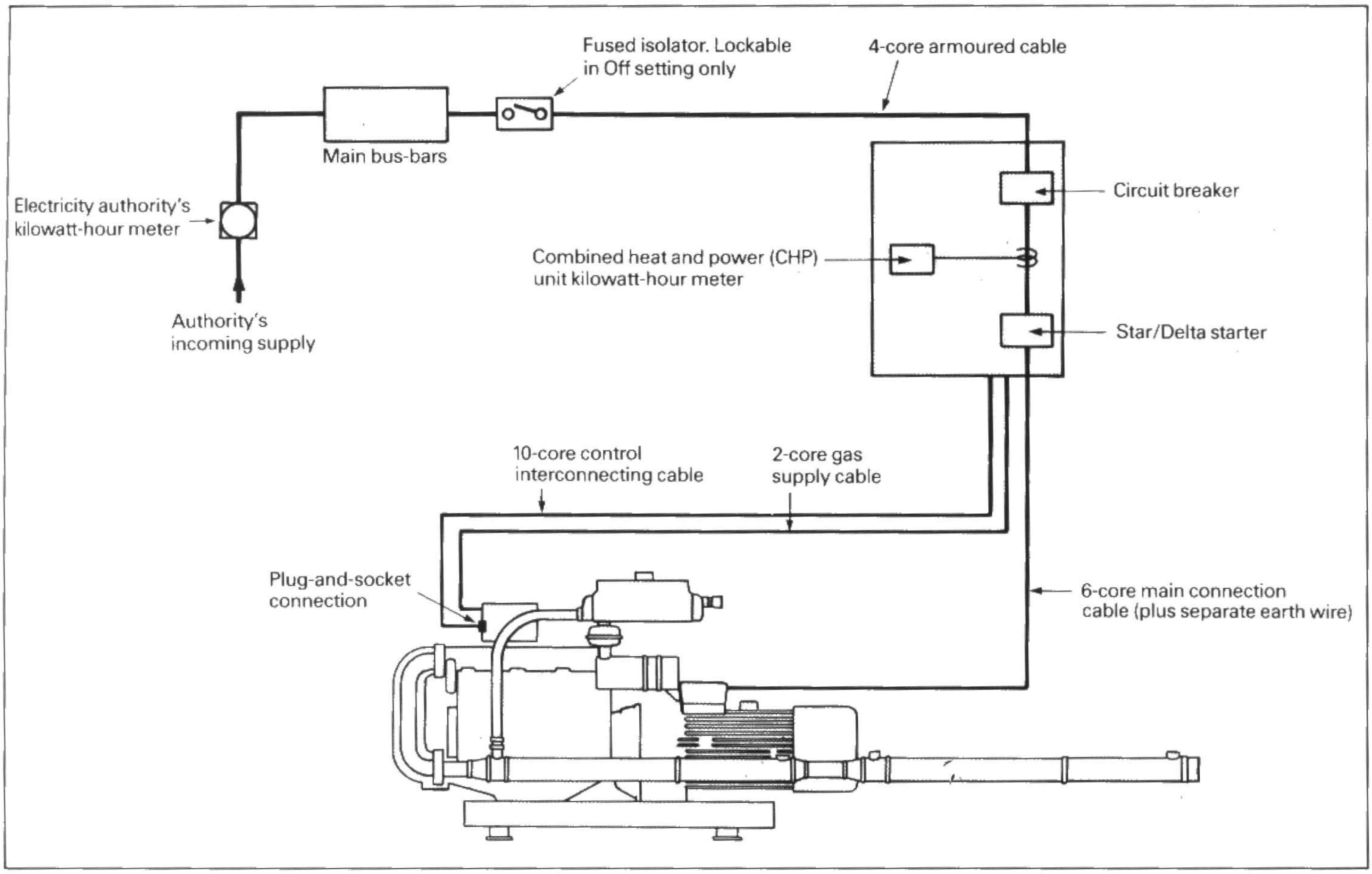
Instead of a radiator to dissipate heat from the engine, as in a conventional standby generator set, heat exchangers are fitted so that this normally wasted heat is profitably used. Places that can benefit economically, include leisure centres, hospitals, residential schools, swimming pools, prisons, hotels and factories, where the recovered heat can be used for central heating and hot water supplies, or perhaps for some industrial process. In effect, the fuel is used twice, once for generating power and a second time for producing heat.

Warm climates

In countries with a warm or hot climate, mini power stations still have such applications because a great deal of the heat load is independent of external temperature, and there will be much more scope for using the engine's waste heat to generate cooling for air-conditioning or refrigeration plant. In such places the waste heat is used to drive an absorption type of heat pump. This is particularly significant in developing countries, where expensive diesel-generated electricity is often used simply to provide air conditioning at very low efficiencies and high cost.

Capturing and using this normally wasted heat dramatically increases the efficiency of power generation because any generating system, whether based on nuclear or fossil fuel, always has to get rid of about two-thirds of the input fuel simply as heat, which means very low overall efficiencies if that heat cannot be used. Moreover, large power stations are usually sited out in the country, away from any building which could use such heat, so they have to waste the heat deliberately in the familiar cooling towers. A further nine per cent is lost in transmission and distribution, which brings overall efficiencies down to about 28 to 30 per cent. By capturing this heat, mini power stations can boast efficiencies over 2.5 times that of a typical large system, thereby allowing them to produce much cheaper power.

In the UK and western Europe, where gas prices are low, the industrial spark



Installation scheme for a 40 kWe station.

ignition engine is favoured for use in mini stations. It is similar to a car engine, but is much more heavily built and is designed for extremely long life coupled with low costs of running and maintenance. The engine can run on a wide variety of fuels including landfill gas, biogas, natural gas, liquid petroleum gas, mine drainage gas and low thermal value gas from wood or crop residue gasifiers. The latest lean-burn engines have electrical efficiencies of 35 per cent, which is better overall than the efficiency of central power generation when distribution losses are taken into account. Depending on local fuel prices, an alternative might be the diesel engine. Dual-fuel engines are ruled out by their high capital cost, maintenance costs and their extra complication. The 3 kWe and 8 kWe units I mentioned earlier are based on a rotary engine. Stirling engines, which offer the possibility of running on coal, are also being looked at closely.

Typical payback times for these applications are two to four years if the equipment is installed by a consumer who can avoid the total costs of electricity supply, or perhaps three to five years if the electricity authority installs the system. Paybacks for a nuclear power station take an amazing 20 to 40 years.

Housing systems

A forthcoming report from the UK Open University's Energy Research Group shows that the technology could be well adapted to modern low-energy houses in the UK, with one 40 kWe unit shared between 40 houses linked by buried hot water pipes. Existing houses would need one 40 kWe unit for 20 houses; this would be equivalent to about 2 kWe of mini power station output per house.

Another idea being worked on by Applied Energy Systems at Watford is the rotary engined mini-power station small enough to fit into individual houses. If successful it will have the advantage that hot water pipes will not be needed to link houses and it will avoid the cost of heat metering.

Comparison with the motor car engine shows that any notion of too many mini power stations being needed is wrong: there are many millions of similarly sized engines fitted in road vehicles today, and production easily keeps pace with the demand. Furthermore, by spreading the electrical source among a large number of sets ensures that the breakdown of a single station has a negligible effect on the whole system, which is not always true of very large central power stations. Put another way, when do all road vehicles break down simultaneously? And what percentage of cars do we see broken down on the motorway? Reliability is endorsed by the fact that industrial engines to drive mini power stations have been used in the oil industry for over 50 years. They are designed for very long life and there are examples that have clocked up the equivalent of 25 years' continuous running.

Sometimes it is alleged that mini stations are economic only because of low fuel prices, which may not last for long. But they convert gas into heat as efficiently as do existing gas boilers, and do not consume any extra gas for generating electricity, so the price of the electricity they produce is largely independent of the gas price. There are, too, mini stations that can run on coal dust if gas were to become prohibitively expensive.

Dave Andrews was until recently an area manager with Applied Energy Systems of Watford and is now a freelance consultant.

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February 1988	14 Jan. 1988	4 Dec. 1987	20 Nov. 1987	Telecommunications
March 1988	18 Feb. 1988	15 Jan. 1988	28 Dec. 1987	Sensors
April 1988	17 Mar. 1988	12 Feb. 1988	29 Jan. 1988	Electrophonics
May 1988	14 Apr. 1988	11 Mar. 1988	26 Feb. 1988	Artificial Intelligence
June 1988	12 May 1988	8 Apr. 1988	25 Mar. 1988	Electronics & Art
July/August 1988	16 June 1988	13 May 1988	29 Apr. 1988	Amateur Radio & TV
September 1988	18 Aug. 1988	15 July 1988	1 July 1988	Computers & Microprocessors
October 1988	15 Sep. 1988	12 Aug. 1988	29 July 1988	Power supplies
November 1988	20 Oct. 1988	16 Sep. 1988	2 Sep. 1988	Optoelectronics
December 1988	17 Nov. 1988	14 Oct. 1988	30 Sep. 1988	Computer-aided test & measurement
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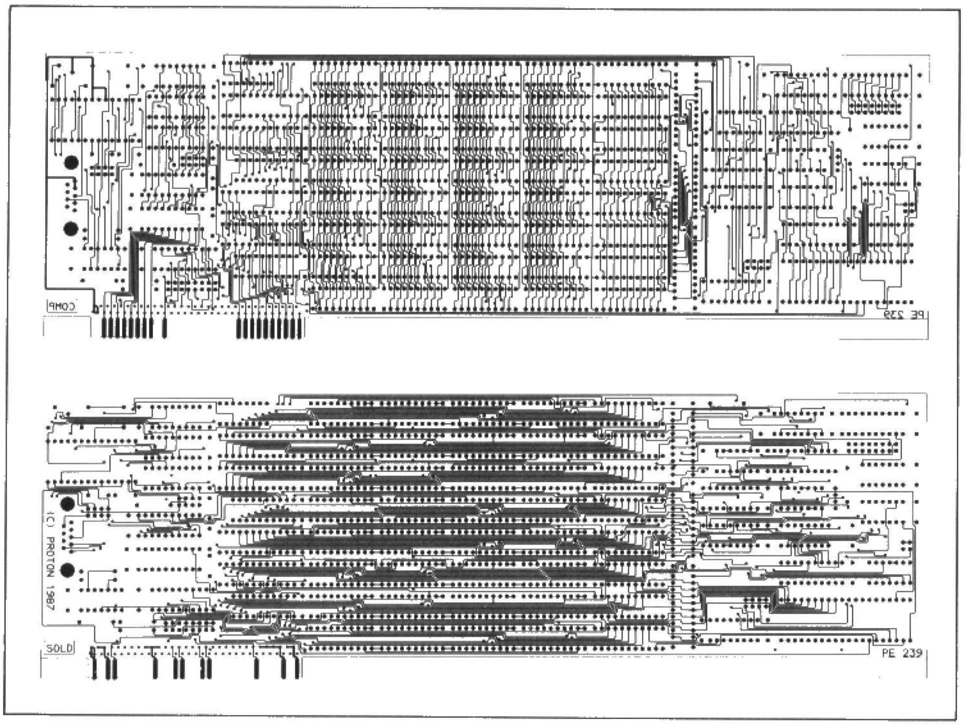

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ULTIboard provides the ultimate assistance to a PCB designer to complete his job fast and accurate.

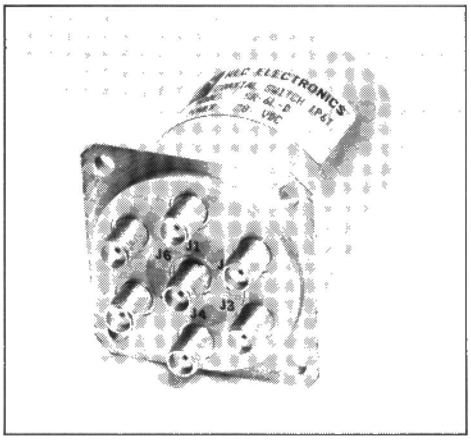
Running on an IBM PC/XT/AT or compatible with high resolution colour graphics and a mouse or graphic tablet, ULTIboard is a powerful software tool for designers who wish to increase their productivity and gain complete control over design quality.

Features of Ultiboard include a fast Real Time design rule check, which prevents illegal connections to other nets and guarantees the specified clearances between traces and spots during layout. Fast graphic editing features enable placing, moving and deleting of traces, via's and components, supported by rubberbanding and rats' nest functions in a way the designer expects, requiring absolute minimal handling. A Placement Evaluation is provided to instantly show the shortest routes when moving a component, allowing optimal placement (in contrast to systems performing rubberbanding only).

Ultiboard works with the EGA of Hi-RES colour graphics board. Resolution is 640×350 (EGA) up to 2048×2048 pixels (Hi-RES) in 16 colours. The Multilayer Capability can handle up to 20 layers, with a real-time design rule checking on all layers concurrently. On-line help offers immediate assistance for the currently selected mode of UltiBoard. The design package works with two screens: one monochrome for user information, and one high resolution colour for the design.

Among the available options is a Netlist Interface (ORCAD, Workview and DASH compatible), SMD support, an Advanced Autorouter, Real-Time Panning and Zooming, and a Gerber photoplotter interface. UltiBoard is available through an international network of distributors. Further information is available from

Tudorgate Limited • 6-7 The Paddock • Hambridge Road • NEWBURY RG14 5TQ. Telephone: (0635) 32872.

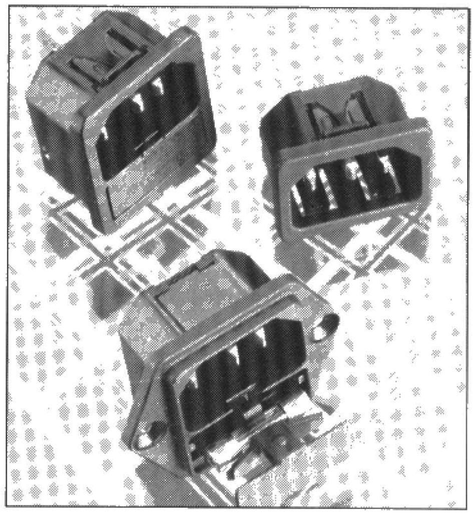


New multi-position RF switches

Pascall Electronics Limited announce the introduction of a new series of multi-position switches, designed to optimize operating power while maintaining the form, fit and function with MIL-S-3928. Designated SR-6L, this series of switches has the same excellent RF capabilities as the SR-6C series presently manufactured to 40GHz.

The SR-6L is available in independent coil operation, from three position to six positions.

Pascal Electronics Ltd • Saxon House • Downside • SUNBURY-ON-THAMES TW16 6RY. Telephone: (01-979) 0123.



The 6100 and 6200 Series snap-in mains inlets from Rendar couple high quality with very low installation costs. Built-in fuseholders are incorporated in the 6200 Series inlets. Access to fuses is safe and easy via a simple sliding-drawer arrangement. Versions are available for a wide range of panel thicknesses. All inlets carry a wide range of International approvals.

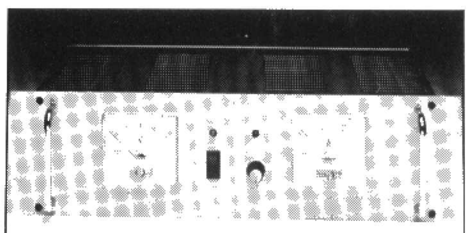
Rendar Limited • Durban Road • South Bersted • BOGNOR REGIS PO22 9RL. Telephone: (0243) 825811. Telex: 86420.

Power supplies with full RF protection

STC Instrument Services has introduced the BNOS PR Series 19in. rack-mounted power supplies which offer full RF protection.

Providing power up to 600 W continuous, the PR Series offers output voltages in three ranges: 2-7 V, 10-15 V and 20-30 V, with output currents up to 40 A.

The Series offers protection against short circuit, overvoltage, and overcurrent with an automatic shutdown facility. Featuring stability of better than 0.01% for 10% line change; 50 Hz input frequency; 240 V input voltage (AC); and 500 μV at maximum continuous output, the series incorporates 'Power On' LED indication.



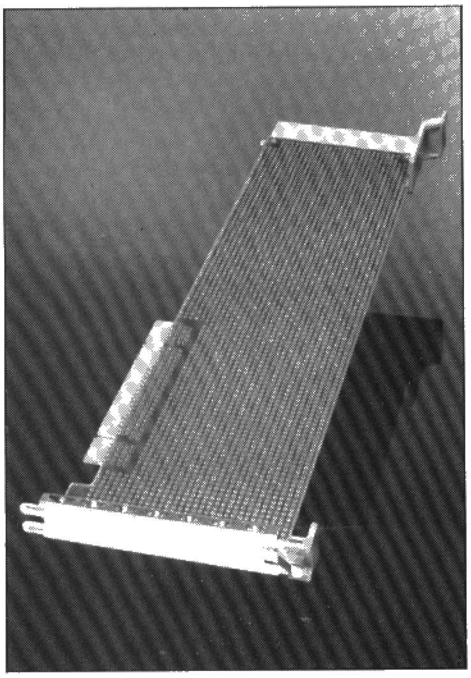
STC Instrument Services • Dewar House • Central Road • HARLOW CM20 2TA. Telephone: (0279) 641641.

NEW PRODUCTS

PS/2 Prototype Board for Micro Channel Architecture computers

The PS/2 prototyping board is a high quality printed circuit board conforming exactly to the new IBM Micro Channel Architecture as used in the Personal System/2 Model 50, 60 and 80 computers.

The prototyping board allows you to make up custom I/O, memory and interface boards for IBM's exciting new range of machines. It is ideal for design houses as a first step in the production of their own PS/2 boards. The prototype card allows users to build their own PS/2 interface boards and so bypasses any shortage in supplies!



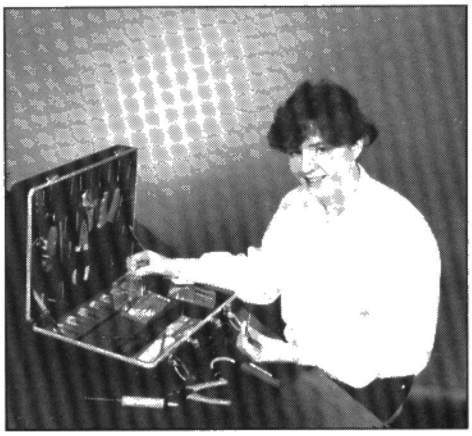
Typical applications of the Prototyping Board include: digital input-output boards, modem card, 16 megabyte memory card, serial port card, ultra high resolution graphics card, Ethernet board, co-processor board for Transputer or Motorola 68020 CPU, truly endless possibilities.

The prototype board costs £ 99.95 + VAT.

Brain Boxes • Unit 3G • Wavertree Technology Park • Wavertree Boulevard South • LIVERPOOL L7 9PF. Telephone: (051 220) 2500. Telex: 8950511 ONEONE G.

The Engineers Elect Toolkit

Toolrange now offer a new comprehensive, competitively priced Engineers Elect Toolkit. This extremely versatile kit is made up of over seventy high quality tools selected for the service technician to provide a practical solution to a huge variety of on-site and workshop problems.



The kit includes a full range of soldering and desoldering tools as well as a range of pliers, cutters and wire strippers. A selection of instrument, electrician's, engineer's and jewellers screwdrivers are included in addition to hex drivers and a trim tool alignment set. Both metric and imperial spanner sets are provided along with files, wrenches, a hammer, knife and hacksaw. Inspection tools and a brush complete the kit.

The case itself is of ribbed ABS shell construction for rigidity and strength, has an aluminium frame, double locks and is fitted with a double-sided removable tool pallet.

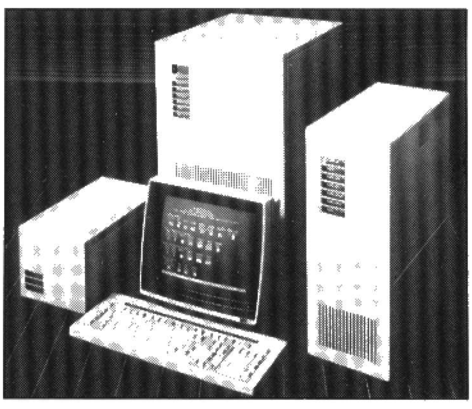
The new Engineers Elect kit from Toolrange is competively priced at £231.00 and availability is ex-stock from Toolrange for 24 hour delivery nationwide.

TOOLRANGE LTD • Upton Road • Reading • Berkshire RG3 4JA. Telephone: (0734) 429446. Telex: 847917. Fax: (0734) 431528.

New uninterruptible power supply

Jidenco has announced a new uninterruptible power supply for microcomputer applications.

From IMO Power, the Micro UPS is designed to operate in critical applications where efficiency and reliability are vital. The Micro UPS employs the latest pulse width modulation techniques to overcome problems such as transients, voltage fluctuations and power outages. The new supply is an 'on-line' UPS system which conditions and cleans the



mains while maintaining the required output.

The first model available is the T-110 which features a power rating of 1000 VA, and back-up times of 38 minutes at 50%, and 22 minutes at full load. The unit weighs 48 kgs.

The new T-110 operates from 118-246 VAC at between 45 and 65 Hz. Output characteristics are 220/230 and 240 VAC ±2% at 50 Hz ±0.5%. Power factor is 0.8 and the waveform is sinusoidal with total harmonic distortion guaranteed to be less than 1%.

Jidenco Machines International Ltd • Components Division • Jidenco House • Vale Road • WINDSOR SL4 5JW. Telephone: (0753) 869723.

Disk-less industrial PCs with diskPROM package

Application programs for PC-compatible STEbus industrial computers can now be blown into silicon, using Arcom's new diskPROM software package. Costing just £95, diskPROM both enhances ruggedisation and reduces costs for control systems. The software runs in conjunction with Arcom's new board set which emulates the IBM PC architecture on the industry-oriented STEbus, offering a simple and widely-supported route to the implementation of computer systems for industrial tasks.

DiskPROM allows system designers to dispense with a disk drive and disk controller board in the final target system. This reduces system cost significantly and extends the target system's ability to cope with harsh environments, increasing tolerance of dust and vibration, and widening the system's operating temperature range.

Arcom Control Systems Ltd. • Unit 8 • Clifton Road • Cambridge CB1 4WH. Telephone: (0223) 411200. Telex: 94016424 ARCS G.